The fore limbs must indeed have been of very little use, and it is very difficult to imagine an animal running and seizing the prey it overtakes with the hind limb. If it were not a carrion feeder it must have leaped. We are informed by Hochstetter,* that the Apteryx leaps with the utmost ease over objects two and three feet in height, that is, higher than its own head. Huxley suggests that the Compsognathus "hopped" along on its hind limbs. The bulk of Lælaps is no objection to its leaping, for the giant extinct Kangaroos, Macropus atlas and titan, found in the postpliocenes of Australia, did not fall far short of these reptiles in this respect. We may add that Lælaps had smaller allies, as L. macropus one-half, and Cœlosaurus antiquus one-fourth or fifth the size, whose remains, so far as they go, indicate an identity of habit. Deslongchamps says of Pœcilopleurum bucklandii, that it "could project itself with prodigious force, as a spring which unbends itself; but this could not have been on a solid surface, since the fore limbs are too weak to resist the shock of the fall of such a heavy body." He supposed it to be marine in its habits, accustomed to battling a stormy sea. However, his objection to leaping on land is obviated by understanding that progressive movement was entirely performed by the hind limbs.

On the Origin of GENERA.

BY EDWARD D. COPE, A.M.

Introduction.—The present fragmentary essay is a portion of what other occupation has prevented the author from completing. It does not therefore amount to a complete demonstration of the points in question, but it is hoped that it may aid some in a classification of facts with a reference to their signification. When all the vast array of facts in possession of the many more learned than the writer, are so arranged, a *demonstration* of the origin of species may be looked for somewhere in the direction here attempted to be followed.

Conclusions of any kind will scarcely be reached, either by anatomists who neglect specific and generic characters, or secondly by systematists who in like manner neglect internal structure. Such will never perceive the system of nature.†

Analysis of the subject.

I. Relations of allied genera.
  First; in adult age.
  Second; in relation to their development.
    α. On exact parallelism.
    β. On inexact or remote parallelism.
    γ. On parallelism in higher groups.
    δ. On the extent of parallelisms.
II. Of retardation and acceleration in generic characters.
  First; metamorphoses in adult age.
    α. The developmental relations of generic and specific characters.
    β. Probable cases of transition.
    γ. Ascertained cases of transition.
  Second; earlier metamorphoses.
    δ. The origin of inexact parallelisms.

* New Zealand Amer. Transl., 181.

† It might seem incredible that either class should systematize with confidence, yet a justly esteemed author writes even at the present day, "However, there is scarcely a systematist of the present day who does not pay more or less attention to *anatomical* characters, in establishing the higher groups!" (The italics are our own,) As though a system was of any value which is not based on the *whole structure*, and as though *lower* groups were only visible in external characters: in a word, as though external (muco-dermal, dental, etc.) characters were not "anatomical!"

III. Relations of higher groups.
  α. Of homologous groups.
  β. Of heterology.
  γ. Of mimetic analogy.
IV. Of natural selection.
  α. As affecting class and ordinal characters.
  β. As affecting family characters.
  γ. As affecting generic characters.
  δ. As affecting specific characters.
  ε. On metaphysical species.
V. Of epochal relations.

The laws which have regulated the successive creation of organic beings will be found to be of two kinds, as it appears to the writer. The first, that which has impelled matter to produce numberless ultimate types from common origins; second, that which expresses the mode or manner in which this first law has executed its course, from its commencement to its determined end, in the many cases before us.

That a descent, with modifications, has progressed from the beginning of the creation, is exceedingly probable. The best enumerations of facts and arguments in its favor are those of Darwin, as given in his various important works, The Origin of Species, etc. There are, however, some views respecting the laws of development on which he does not dwell, and which it is proposed here to point out.*

In the first place, it is an undoubted fact that the origin of genera is a more distinct subject from the origin of species than has been supposed.

A descent with modification involves continuous series of organic types through one or many geologic ages, and the co-existence of such parts of such various series at one time as the law of mutual adaptation may permit.

These series, as now found, are of two kinds; the uninterrupted line of specific, and the same uninterrupted line of generic characters. These are independent of each other, and have not, it appears to the writer, been developed pari passu. As a general law it is proposed to render highly probable that the same specific form has existed through a succession of genera, and perhaps in different epochs of geologic time.

With regard to the first law of development, as above proposed, no one has found means of discovering it, and perhaps no one ever will. It would answer such questions as this. What necessary coincidence of forces has resulted in the terminus of the series of fishes in the perches as its most specialized extreme; or, of the Batrachia, in the fresh-water frogs, as its ultimum; or, of the thrushes, among birds, as their highest extreme: in a word, what necessity resulted in man as the crown of the Mammalian series, instead of some other organic type? Our only answer and law for these questions must be, the will of the Creator.

The second law, of modes and means, has been represented to be that of natural selection by Darwin. This is, in brief, that the will of the animal, applied to its body, in the search for means of subsistence and protection from injuries, gradually produces those features which are evidently adaptive in their nature. That, in addition, a disposition to a general variation on the part of *species* has been met by the greater or less adaptation of the results of such variation to the varying necessities of their respective situations. That the result of such conflict has been the extinction of those types that are not adapted to their immediate or changed conditions, and the preservation of those that are.

In determining those characters of plants and animals, which constitute them what they are, we have, among others of higher import, those which constitute them species and those which constitute them genera. What we propose is: that of the latter, comparatively very few in the whole range of animals and

plants are *adaptations* to external needs or forces,—and of the former a large proportion are of the same kind. How then could they owe their existence to a process regulated by adaptation?

Darwin is aware of these facts to some degree, but, as already said, he does not dwell on them. Where he does, he does not attempt to account for them on the principle of natural selection.

There are, it appears to us, two laws of means and modes of development. I. The law of acceleration and retardation. II. The law of natural selection.

It is my purpose to show that these propositions are distinct, and not one a part of the other: in brief, that while natural selection operates by the "preservation of the fittest," retardation and acceleration act without any reference to "fitness" at all; that instead of being controlled by fitness, it is the controller of fitness. Perhaps all the characteristics supposed to mark generalized groups from genera up (excepting, perhaps, families), to have been evolved under the first mode, combined with some intervention of the second, and that specific characters or *species* have been evolved by a combination of a lesser degree of the first with a greater degree of the second mode.

I propose to bring forward some facts and propositions in the present essay illustrative of the first mode.

I. *On the relations of nearly allied genera.*

First. The writer's views of the relations of genera have already been given at the close of an Essay on the Cyprinoid Fishes of Pennsylvania.* It is easy enough to define isolated genera which have few immediate affines, but among extensive series of related forms the case is different. One principle, however, pervades the conception and practice of all zoologists and botanists, which few take pains to analyse or explain. It is simply that they observe a successional relation of groups, by which they pass from one type of structure to one or several other types, and the presence or absence of the steps in this succession they regard as definitions of the genera.

It is true that the reader will often find introduced into diagnoses of genera, characters which indicate nothing of this sort. It is often necessary, indeed, to introduce characters which are not peculiar to the genus characterized, for the sake of distinguishing it from similar ones of *other series*, but this only in an imperfect state of the record. Moreover, the ability of the writer to distinguish genera being thus tested, he too often fails by introducing family and specific characters, or by indulging in an unnecessary redundancy. In general it may be said that adjacent genera of the same series differ from each other by but a single character; and generally, that the more remote differ by characters as numerous as the stages of their remove.

It is precisely as, among the inorganic elements, we pass from the electro-negative, non-oxidizing extreme of the Halogens, with Fluorine as the extreme, to the electro-positive, violently oxidizing extreme of the alkaline metals, whose extreme is potassium, by steps whose relative position is measured or determined first by these tests; and as these steps have each their included series of bodies, characterized by their successive relations on the lower level of a subordinate range of characters. This principle is distinctly admitted by many zoologists;† those who deny it generally failing to perceive it because they attempt to guage a major scale by characters which are really the test of one or all of the subordinate or included scales. It holds true of most of the groups of organic beings; thus the class is a scale of orders, the order of tribes. I will not now say that the tribe is a scale of families, as the case is here much modified, but what is chiefly to be considered in this essay, is that the family is composed of one or several scales of genera.

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*Trans. Amer. Philos. Soc., 1866, from Proc. Acad. Nat. Sci., Phil., 1859, 332.

†Prof. Bronn, in his Classen u. Ordnungen des Thierreiches, has everywhere a chapter on Die aufsteigende Reihe,—"the ascending scale."

Second. Now, the more nearly allied genera are, the more surely will these generic steps be found to fall into the direct line of the steps of the development of the highest, or that with the longest scale, the former being truly identical with the latter in generic characters. Less allied genera will offer an inexact or incomplete imitation of such identity,—some additional character being present to disturb it. Such genus belongs to another series, characterized by the disturbing feature, whose members, however, bear to each other the relation claimed above for such.

The relation of genera, which are simply steps in one and the same line of development, may be called *exact parallelism*, while that of those where one or more characters intervene in the maturity of either the lower or higher genus to destroy identity, may be called *incomplete parallelism.*

The latter relation has been dwelt on by Von Bär, Agassiz and other writers, but none have accepted the existence of *exact parallelism*, or seen its important relation to the origin of genera.

Third. That the lowest or most generalized terms or genera of a number of allied series, will stand to each other in a relation of exact parallelism. That is, if we trace each series of a number, up to its lowest or most generalized genus, the latter together will form a series, similar in kind to each of the sub-series; *i. e.* each genus will be identical with the undeveloped conditions of that which progresses the farthest, in respect, of course, to the characters which define it as a series.

Those characters of the skeleton which we are accustomed to call embryonic, are only so because they relate to the developmental succession witnessed in animals at the present time. Characters not so called now were probably as much so at one period now passed. Hence embryonic characters of the bony system do not, as I have often had occasion to observe, characterize the types of the highest rank, but only subordinate divisions of them. Thus the Elasmobranchs are probably repressed forms of groups of a really higher grade than the bony fishes, or Teleostei, which may be known to us. In their early presence in the geologic series we have evidence of the first beginning of a higher type.

In the same manner it has been discovered that the molecular constitution of the elementary substances do not characterize their highest or most distinct series, but rather the substances themselves within the lower group or family to which they belong. The gaseous, liquid and solid molecular conditions being characters distinguishing otherwise allied substances in the same way morphologically (we cannot say yet developmentally), as the cartilaginous, osseous and exostosed or dermosseous characters distinguish otherwise nearly allied genera.

The "family" group embraces one or many of such series. If we trace the series in several families to their simplest or most generalized terms or genera, and compare them, we will not find the relation to be one of exact parallelism in the series of the "order," so far as our present knowledge extends, but in a developmental sense, one of divergence from the commencement.

If we could know the simplest known terms or family characters of a number of groups of families, or "orders," we would probably find them to represent a series of exact parallelism, though to find such simplest terms we must go far into past periods, since the higher the group the more extensive the range of its character, and the less likely to be found unmixed with additions and extensions, in modern times.

Finally, the series of classes is in the relation of the essential characters of the same, as expressed in their now extinct, most generalized and simple representatives, also one of "exact parallelism."

α. Examples of exact parallelism.

* In generic series.

1. As an example we may take the genus Trachycephalus (Batrachia Anura).

Nearly allied to it is the genus Osteocephalus, which differs in the normal exostosis of the cranium not involving the derm, as in the former. Close to this is Scytopis, where the fully ossified cranium is not covered by an exostosis. Next below Scytopis is Hyla, where the upper surface of the cranium is not ossified at all, but is a membranous roof over a great fontanelle. Still more imperfect is Hylella,* which differs from Hyla in the absence of vomerine teeth. Now the genus Trachycephalus, after losing its tail and branchiæ, possesses all the characters of the genus Hylella and those of Hyla, either at or just before the mature state of the latter, as the ethmoid bone is not always ossified in advance of the parietals. It soon, however, becomes a Scytopis, next an Osteocephalus, and finally a Trachycephalus. It belongs successively to these genera, for an exhaustive anatomical examination has failed to reveal any characters by which, during these stages, it could be distinguished from these genera.

Now it would be a false comparison to say that the young of Trachycephalus was identical with the genus Agalychnis, which in truth it resembles, because that genus is furnished with one other character,—the presence of a vertical pupil,—and belongs to another series in consequence, which is represented as yet, with our present imperfect knowledge,—or perhaps imperfect fauna,—by three genera only.

2. The lowest type of the near allies of our common fresh-water frogs is the genus Ranula, where the prefrontal bones are narrow strips on each side the ethmoid cartilage; the ethmoid cartilage itself entirely unossified above, and the vomerine teeth very few and on a small elevation. There are two species, R. affinis and R. palmipes. The other species have the ethmoid cartilage ossiffied above, at least beneath the extremities of the frontoparietals.

Those of the latter most like Ranula possess the same type of narrow prefrontals, separated by a broad area of cartilaginous ethmoid, and fasciculi of teeth. Of this type is Rana delalandii, and probably R. porosissima Steind., of the South Ethiopian region. Other species of the same type extend their vomerine patches into lines; such are R. mascariensis, R. fasciata, R. oxyrhynchus, R. grayi, and other South African species.

The prefrontals are subtriangular, and approach each other more or less in the numerous species of North America and of the Regio Palæarctica, while generally the vomerine teeth are in fascicles or very short series. In the Æthiopian Rana fuscigula the prefrontals unite on the median line, roofing over the ethmoid cartilage and reducing it, while the vomerine teeth are in very short lines.

In the species of the Palæotropical region, Rana tigrina, R. vittigera, R. cyanophlyctis, R. grunniens, R. hexadactyla, R. corrugata, R. ehrenbergii, R. gracilis, and the Æthiopian R. occipitalis, the prefrontals not only unite solidly (the suture remaining on the median line), but extend and closely fit to the fronto parietals. The vomerine series have lengthened out into series.

Now the young of the latter type of Rana (I take as an example the R. tigrina, one of the most abundant and largest of Indian frogs) presents the subtriangular prefrontals neither in contact with each other or with the fronto-parietals, and the vomerine series is much reduced; in fact, it belongs in all respects to the Palæarctic group. I have not examined younger specimens, but have no doubt they are like those of the Palæarctic; the latter, then, in their young stage, are precisely of the type of the Æthiopian Rana, with fasciculate teeth like the young of those of the same region with teeth in series, since the prefrontals are still more reduced, becoming linear. Finally the first stage of the Nearctic Rana, after losing the larval tail, is the genus Ranula, having linear prefrontals, minute vomerine teeth, and the ethmoid ring cartilaginous above.

These points of structure are of generic quality, but I have not regarded any

*I refer to H. carnea m., not having Reinhardt and Lütken's type of this genus.

group as sufficiently defined to be so regarded, except Ranula, as the adults of some species appear not to be constant in possessing them. Thus a very large Rana catesbyana sometimes exhibits prefrontals in contact on the median line, while it is difficult to say whether R. areolata of North America is of the Nearctic type so much as of the Æthiopian. Nevertheless the groups are generally quite geographically restricted.

3. A similar relation exists between the genera Hyperolius, Staurois and Heteroglossa in respect to the prefrontal bones and the separation of the outer metatarsi, and—

4. Between Ixalus, Rhacophorus and Polypedates also, in reference to vomerine teeth, bifurcation of last phalange, and dermoössification of the cranium.

5. When the larvæ of certain species of Spelerpes possess branchiæ, they also lack one digit of the hind foot, also the maxillary, nasal and prefrontal bones, and exhibit a broad continuous palatopterygoid arch, in close contact with the parasphenoid. The proötic is separated from the exoccipital by a membranous space, and the exoccipitals themselves are not yet united above the foramen magnum. There is at the same time a series of splenial teeth. Both ceratohyals are confluent, the posterior is present, and there are but threé superior hyoid arches. After they lose the branchiæ, the hinder foot, which has four toes only for a time, gradually adds another at first rudimental digit, in the Mexican species; in most North American species the fifth digit appears at an early larval stage. Five digits are finally present in all Spelerpes.

We have thus four combinations of the above characters, at different periods of the life history of certain (but not of all) of the species of Spelerpes. There exist four permanent series of species or genera, equivalent to these stages. The well-known "perennibranchiate" Necturus is nearly identical with the first, Batrachoseps with the second, the half-toed Spelerpes with the third, and the typical Spelerpes is the last.

In one character of generic value only, do I find that Necturus differs from the early larval Spelerpes. It closes the premaxillary fontanelle with which it commences, by an approximation of the premaxillary spines, but not by a sutural union, as takes place in Amblystoma. It thus, in this one point, advanees a stage beyond the condition to which Spelerpes attains, though it may be a question whether such a closure without union should not be classed among the specific characters by which N. maculatus differs from the young of the various Spelerpes, as they do from each other. Characters of the latter kind are the following: in N. maculatus the frontals are more deeply emarginate behind; it has little or no ala on the inferior keel of the caudal vertebræ, which is prominent in Spelerpes larvæ.

It may be that the parallelism in the case of Spelerpes is inexact by one character, and that a strictly developmental one; or it may be regarded otherwise.

6. It is well known that the Cervidæ of the old world develope a basal snag of the antler (see Cuvier, Ossem. Fossiles; Gray, Catal Brit. Mus.) at the third year; a majority of those of the New World (genera Cariacus, Subulo) never develop it except in "abnormal" cases in the most vigorous maturity of the most northern Cariacus (C. virginianus); while the South American Subulo retains to adult age the simple horn of the second year of Cervus.

Among the higher Cervidæ, Rusa and Axis never assume characters beyond an equivalent of the fourth year of Cervus. In Dama the characters are on the other hand assumed more rapidly than in Cervus, its third year corresponding to the fourth of the latter, and the development in after years of a broad plate of bone, with points, being substituted for the addition of the corresponding snags, thus commencing another series.

Returning to the American deer, we have Blastocerus, whose antlers are identical with those of the fourth year of Cariacus.

Now, individuals of the genus Cervus of the second year do not belong to Subulo, because they have not as yet their mature dentition. Rusa, however, is identical with those Cervi whose dentition is complete before they gain the antlers of the fifth year. When the first trace of a snag appears on one beam of Cariacus virginianus, the dentition includes the full number, but there remain $\frac{1}{3}$ milk molars much worn and ready to be shed. Perhaps the snag is developed before these are displaced. If so, the Cariacus is never a Subulo, but there can be little doubt that the young Blastocerus belongs to that genus before its adult characters appear.

7. Leidy states* that certain Perissodactyle remains containing a foot of a horse, contained the teeth of a genus, Merychippus, which has the permanent teeth of Equus, and the deciduous dentition of Anchitherium. He observes "the deciduous and permanent dentitions of both these genera are alike, therefore the new genus is in early life an Anchitherum, and later in life a true horse." This is therefore a case of exact parallelism, always providing that the Merychippus has not added to its immature Equine characters, others in other parts of the body, which invalidate the indentity. In the latter case, it will still be an interesting example of the "inexact parallelism."

8. It is well known that the Cephalopoda form a number of series of remarkable regularity, the advance being in the first place in the complication of the folds of the external margins of the septa, and in the second place in the degree of involution of one or both extremities of the shell to the spiral; third, in the position of the siphon.

Alpheus Hyatt, in an important essay on this subject,† points out that the less complex forms are in many cases identical with the undeveloped conditions of the more complex. He says: "There is a direct connection between the position of a shell in the completed cycle of the life of this order, and its own developement. Those shells occupying the extremes of the cycle" (in time), "the polar forms, being more embryonic than the intermediate forms.‡ The first epoch of the order is especially the era of rounded, and, in the majority of the species, of unornamented shells with simple septa; the second is the era of ornamentation, and the septa are steadily complicating; in the third the complication of the septa, the ornamentation, and the number of species, about twice that of any other epoch, all combine to make it the zenith of developement in the order; the fourth is distinguishable from all the preceding as the era of retrogression in the form, and partially in the septa.

"The four periods of the individual are similarly arranged, and have comparable characteristics. As has been previously stated, the first is rounded and smooth, with simple septa; the second tuberculated, and the septa more complicated; the third was the only one in which the septa, form and ornamentation simultaneously attained the climax of individual complication; the fourth, when amounting to anything more important than the loss of a few ornaments, was marked by a retrogression of the whorl to a more tabular aspect, and by the partial degradation of the septa."

I will here quote an entirely antagonistic statement of Bronn's,§ as follows: In the development of Lamellibranchiate molluscs "it is not possible to estimate the successional changes of one genus by those of another, though nearly related; so diverse are the most significant relations in the manner of progress

* Proceed. Acad. Nat. Sci., 1858, p. 7.

† Memoirs Boston Soc. N. Hist, 1866, 193.

‡ He adds here: "Although in regard to geological sequence and structural position one of the extremes must be of higher geological rank." The "*highest*" extreme will be of higher geological rank according to the complexity of structure and length of developmental scale, whether it come at the middle or end of the history of the class in time. If, as has been the case so far as known, a decline has terminated the history of a class, its later forms are zoologically *lower* than its older ones. Hence the adjective *high* is only appropriate to types of the latter kind, when used as synonymous with extreme.

§ Classen u. Ordnungen des Thierreichs, iii, 445.

among nearest allies. Therefore embryologic indications are throughout useless in classification, and it is necessary to keep carefully separate the statements of observations on development of a given species, and not transfer such facts to the history of another species for the purpose of completing it. We cannot even range these histories in conformity with family groups." For us this statement, though no doubt largely true, is an indication of imperfection, first, of knowledge of true affinities of recent, but especially of extinct adults, and second, of imperfection of knowledge of development. The position appears to be based on negative evidence, while the opposing can and does stand on nothing but positive.

β. Examples of the inexact parallelism.

1. The genera of the Batrachian family Scaphiopodidæ form a series of steps differing a little more than as repressions or permanent primary conditions in the development of the highest.* Thus two of the genera, which are North American, maintain their tubæ eustachii and tympanum through life, while three European lose them at an early period. The three European genera also advance beyond the larval character of the American in the ossification of the basis of the xiphisternum into a broad style. Thus we have two series established, which differ only in the two characters named. Each shows its developmental steps in a similar manner, the European series extending further; thus,—

	European.	*North American.*
1. Temporal fossa over arched.		
	Cultripes.	* *
Temporal roof not ossified.		
2. Fronto-parietal bones ossified, involving derm.		
	Pelobates.	Scaphiopus.
3. Fronto-parietals ossified, distinct from derm.		
	* * (Unknown.)	* *
4. Fronto parietals not ossified, distinct from derm.		
	Didocus.	Spea.

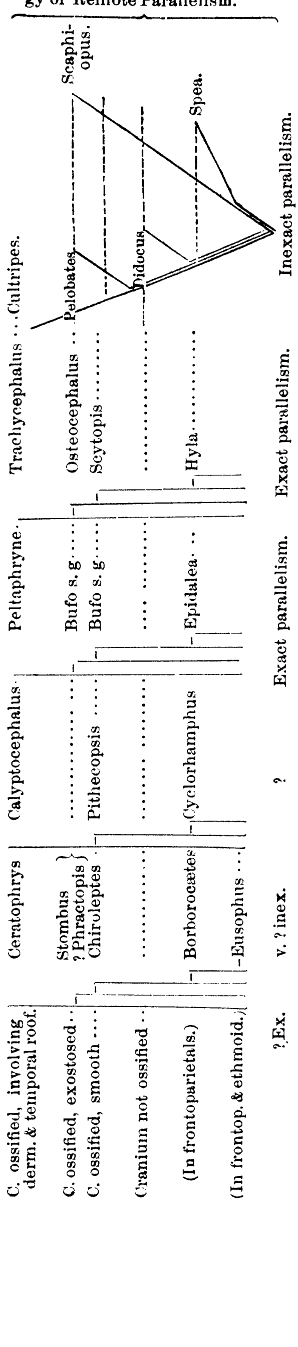
In this case Didocus cannot be said to be identical as a genus with an undeveloped stage of Cultripes, since while the cranium of the latter is in the condition of Didocus it bears a long tail, and the limbs are but little developed. Nor is Didocus identical with the undeveloped condition of Pelobates, since both cranium and limbs of the latter are developed before the tail is absorbed. Nor is Pelobates identical with the undeveleped condition of Cultripes, since while the cranium of the latter is that of the former, the limbs and tail are still larval. The same relations exist between the other members of the family. The genus Scaphiopus is not an undeveloped form of Pelobates as to its auditory organs, for when the latter is identical with the former in this respect, it bears otherwise entirely larval characters. Nor is Spea an arrested Scaphiopus, the relation being here precisely that between Didocus and Pelobates. Spea approaches more closely an arrested Didocus in all respects, but that when the latter posesses the auditory apparatus† of the former, it is a larva in limbs and tail, and that it loses this apparatus before reaching the other characters of Spea. The relations of these genera, as compared with those of the Trachycephalus, Cystignathidæ and Bufo series, may be represented as follows: the lines represent the developmental scale of each.

* See Journal Academy, 1866, on Arcifera.

† The possession of cavum tympani and tuba Eustachii in the undeveloped condition of this genus is only assumed from its close relation to Pelobates.

‡ According to Bruch and Tschudi in Pelobates. I have found traces of the eustachian diverticula in a tailed Pelobates fuscus, whose body measured 1 in. 4 lin., from Mus. Peabody. Institute, Salem, Mass.

elations between the terms of the different series, Heterology or Remote Parallelism.



This is an example of the simplest case of inexact parallelism, as distinguished from the exact parallelism or identity. As the fauna of the present period is but a fragment, so the simple inexact is a more frequent relation than the exact, while the more complex inexact relation is still more common. The greater the inexactitude, the more frequently do such parallels occur, till we have those of the most remote character, as, for instance, the parallelism between the different stages of the development of the mammal, in the structure of the heart and and origins of the aorta, and the existing classes of vertebrates. The relation of these facts to the origin of genera will be noted hereafter.

It will be borne in mind that in the Scaphiopodidæ the generic types are identical for a long portion of their developmental history.

2. In both Perissodactylous and Artiodactylous Mammalia, certain types develop their family character of canines at the earliest appearance of dentition, others not till a comparatively late period of life (Equus), and the extreme genera never produce them.

3. Among Cetaceans the genus Orca maintains a powerful and permanent series of teeth, which is an important generic character. In Beluga the series is shed in old age, in Globiocephalus, or the Caing whales, they are shed at middle age, while in the Balænidæ, of which the absence of teeth is an essential character, these organs are developed and absorbed *during fœtal life* (Eschricht). Though the condition of the teeth is not of systematic value in the two named intermediate genera, it is the important feature in the history of progress to such value.

4. Among the tortoises, the Testudinidæ rapidly extend the ribs into a carapace, which fits closely the marginal bones, while equally early in life the elements of the sternum unite together. This is also the case with most Emydidæ; among whose genera, however, we find the transitional scale. In Dermatemys and Batagur the carapace is very late in attaining its complete ossification, while the plastron is early finished. In Chelydra, on the other hand, while the carapace is even more slowly developed, the plastron is never free from its larval fontanelles. In the marine turtles neither plastron or carapace is ever completed, while in the Trionychidæ the marginal bones are also entirely undeveloped.

In order that this last illustration be a true one for the theory in question, as applied to the *families*, these developmental characters

should be the true distinctive features of these families respectively. This, as is well known, they are not. The Cheloniidæ are characterized by the form of their anterior limbs, which is in an adapted structure, while the Testudinidæ similarly are distinguished by an extreme opposite modification of foot-structure, adapted to an extreme difference of habit. Here there is an example of the co-working of both laws. Nevertheless, we only claim at present to show the developmental relation of *genera* of the same family and the same series. This we see among the Emydidæ.

5. In the important character of the scutellation of the tarsi among the Passerine birds, the "boot" appears early in life in the highest Oscines, later in the lower, and does not appear at all in the majority. In respect to the still more important feature of the long posterior plates which appear very early in most Oscines, in the Myiadestes type* they appear late, the squamæ remaining long, while the Clamatores never develop the plates, not advancing beyond the infantile squamous stage.

6. It has been shown by Falconer that the genera of great Proboscidians form a remarkably regular and graded series, distinguished by their dentition. These are Dinotherium Kaup, Trilophodon Falc.,† Mastodon Cuv., Pentalophodon Falc., Stegodon Falc., Loxodon F. Cuv., and Elephas Linn. In the first there are but two cross crests on the third molars, and a pair of permanent mandibular tusks; in the second, three cross crests and mandibular tusks only permanent in some males; in the third, four cross crests and the mandibular tusks all deciduous; in the fourth, five cross crests on the third molar; tusks unknown. In Stegodon the tusks cease to appear, the crests of the third molar become more numerous, and embrace between them, in the bottoms of the valleys, a strong deposit of cementum. In Loxodon the crests have the whole interspaces filled with cementum, while the same thing holds in Elephas, with a greatly increased number of cross crests, which become vertical laminæ. The laminar character has become apparent from its rudimental condition in Stegodon.

Now these are stages of development, though not in a continuous, single line. The shedding of the inferior tusks takes place earlier and earlier in the genera from Dinotherium, till they never appear in Stegodon. The molar teeth, it is well known, present, as they succeed each other from back to front, a regularly increasing number of transverse crests in the same species. Thus, in Trilophodon ohioticus the first molar presents but two, while the last presents six. The last molars of other genera present a very much increased number. What is it then, but that the increased number of crests in the third molar, definitive of these genera, is an acceleration of growth; the fourth in Trilophodon is structurally third in Mastodon, and the fourth of Mastodon being third in Pentalophodon, the fourth of Pentalophodon becoming third in Stegodon, and so to the end? This is confirmed from the proven fact of the disappearance of the premolars. They are fewer in Trilophodon‡ than in

* Baird, Review Birds N. America.

† The genus Mastodon, as left by Cuvier, embraced two genera, as has been clearly shown by that excellent palæantologist, the late Dr. Falconer. He named these genera Trilophodon and Tetralophodon. It appears to us that this was unnecessary, as he was aware that Dr. Godman had named the American Mastodon Tetracaulodon from its sometimes persistent inferior tusks, a character distinguishing it from the later genera of the series, though not so trenchantly as the three crests of its third molar, as pointed out by Falconer. As this group was taken from the Cuvierian Mastodon, it should retain Godman's name, for the T. ohioticus, the T. angustidens and T. humboldii, while Cuvier's name should be preserved for the remainder, viz., M. longirostris, M. borsoni, M. arvernensis, etc., the *Tetralophodons* of Falconer.

‡ The two-crested and first three-crested molars are usually called milk molars, because early shed. As, however, they are not succeeded by any subsequent teeth, but are similar to those which lie behind them in the jaw, I cannot see why they are not true premolars. Dr. Warren, in his monograph of Mastodon ohioticus, says "This is called the third deciduous tooth, but why it is more entitled to this epithet than the two which follow it would be difficult to determine. Are not the first and second so-called permanent teeth equally deciduous, since they are shed, and leave the last permanent molar solitary?" V. p. 69. Flower says (Transac. Royal Society, 1867. 638), "In the Dugong and in the existing Elephants the successional process is limited to the incisor teeth."

Dinotherium, and soon shed; they are also early shed in Mastodon and Stegodon (insignis Falc. Caut.) and are not known to exist in the succeeding types; the acceleration of succession of teeth has caused them to be entirely omitted. The young tooth of Elephas moreover is represented by a series of independent parallel laminæ at first, which, when they unite, form a series of crests similar to the type of the genus Mastodon and others of the beginning of the series. The deposit of cementum takes place later, till the valleys are entirely filled up. Thus the relations of this part of the tooth structure in the series are also those of the successional growth of those of Elephas, or the extreme of the series.

It would be only necessary to show that two distinct conditions in any of these respects occurred among the different individuals of the same species of any of these genera, to render a hypothesis of evolution a demonstrated fact.

It must be here observed that great size indicates little or nothing as to zoological rank. It merely indicates the expenditure of a large amount of stored vegetative force in the individuals of the group, however limited, which exhibits it. The greatest species are often not far removed in affinity from the least; thus there can be but little doubt that Elephants are not far removed from the Rodents, and the Rhinoceros is near the Cony. Indeed, in the same genus the most extraordinary diversity prevails, for we have a very small Elephant of Malta, and in the Miocene of Maryland a fin-back whale not so large as the new-born young of the fin-backs now living. Hence Prof. Dana's objection* to the developmental hypothesis, based on the great size of the primal Selachians and Ganoids, has but little weight.

7. Rathke has shown that the arteria ophthalmica of the higher Ophidians is originally a branch of the arteria cerebralis anterior, and that it later forms a connection with the arteria facialis. This connection increases in strength, while the other diminishes, until finally its supply of blood is derived from the facialis instead of the cerebralis.

Rathke has also shown that the cerebral origin of this artery is continued through life in the three lowest suborders of the serpents, the Scolecophidia, Catodonta and Tortricina; also in the next succeeding group, the Peropoda.

8. In most serpents the left lung is never developed; in such the pulmonary artery instead of being totally wanting, remains as a posterior aorta bow, connected with the aorta by a ductus botalli; serpents without left lung being therefore identical in this respect with the embryonic type of those in which that lung exists.

9. Dr. Lespes states that the optic region of the brain of blind cave Coleoptera, examined by him, is similar in structure to that in the blind larvæ of Coleoptera, whose imagos possess visual organs.

† 10. Those Saurians, (Uromastix, etc.,) in which the premaxillary region is produced into a uniform cutting edge, are furnished during early stages with a series of premaxillary teeth, which become gradually fused and confluent with the alveolar margin. Hence other Acrodonts are equivalent, in this respect, to the young of Uromastix, etc. The same thing occurs among the Scaroid and Labroid fishes. In this most natural family we find the majority of generic forms provided with a normal complete dentition; in others (Chaerops, Xiphochilus, Pseudodax, etc.,) the lateral teeth are gradually and normally replaced by a more or less cutting edge of the mandible; and finally, in the Scarina and Odacina the entire mass of teeth and jaws are coalesced, forming a beak with sharp cutting edges, the single teeth being still visible in the true Scarus, while they have entirely disappeared in adult Pseudoscarus and Odax.‡ Thus in dentition the adult Scarus is identical with not fully developed Odax; Chaerops with the teeth less confluent, equals a still younger

* Manual of Geology, p.

† See under section on acceleration and retardation.

‡ Günther on Hatteria, Philosophical Transactions, 1867, II. I had already noticed the peculiar development in Uromastix, but not published it.

stage of Odax, while those with distinct teeth are the same in this point as the embryos of the highest—Odax, etc. I venture to predict that here will be found a long series of *exact parallelism*, in which the different genera, resting exclusively on these dental characters, will be found to be *identical* generically with the various stages of the successively most advanced.

11. Professor Agassiz states that the absence of ventral fins is characteristic of an embryonic condition of the Cyprinodont fishes. The genus Orestias does not progress beyond this stage in this one point. Probably the genus will be found which will only differ from Orestias in the presence of ventral fins. If so, Orestias will be identical with an imperfect stage of that genus, if, as will probably be the case, the fins appear in the latter, after other structures are fully completed.

γγ. *Parallelism in Higher Groups.*

It is not to be anticipated that the series of genera exhibiting exact parallelism can embrace many such terms, since comparatively few stages in the developmental condition of the same part in the highest, would bring us back to a larval condition, which, as far as we yet know, has no *exact parallel* among existing genera. But it is to be believed that the lowest terms of a number of the most nearly allied of such series, do of themselves form another series of exact parallelisms.

Thus exact parallelism between *existing* genera of mammals ceases with all characters which are larval or fœtal only prior to the assumption of the adult dentition, since among the higher mammalia at least we know of no genus which, however similar to undeveloped stages of the higher, never loses the milk dentition. It is nevertheless an important fact that, among smooth brained mammals, or many of them, but one tooth of the second series appears; and inasmuch as smooth brained forms of the higher orders have become extinct, it is not too much to anticipate that a type of permanent milk dentition will be found among the extinct forms of the same high orders.

As an example of exact parallelism in series of series, I select the following:

1. in the Batrachian family Cystignathidæ there are six groups or sets of genera. In the highest of these we have an ossified cranium and xiphisternum —i. e. in the Cystignathi; in the Pleurodemæ the cranium is not ossified, thus representing the Cystignathi while incomplete; in the Criniæ the xiphisternum is cartilaginous, as well as the fronto-parietal region, being an equivalent of a still lower stage of the Cystignathi. From this simplest type we can find a rising series by a different combination of characters; thus the Ceratophydes add an osseous cranium to the incomplete xiphisternum, while two succeeding groups diverge from each other at the start, the Pseudes loosening the outer metatarsus in their development to maturity, while the Hylodes add by degrees a cross-limb to the last phalange. The Ceratophrydes and Criniæ are stages in the development of these, but neither one of them is a step in the development of the other. They are measured by adaptive characters purely.

2. The whole suborder of the Anurous Batrachia, to which the above family belongs, the Arcifera, differs from the suborder Raniformia by a character which distinguishes a primary stage of growth of the latter from its fully developed form. That is, the Raniformia present, at one period of their development, a pair of parallel or over-lapping curved cartilages, connecting the the procoracoid and coracoid bones, which subsequently unite and become a single, slender median, scarcely visible rod, while the bones named expand and meet. The first condition is the permanent and sole systematic character of the Arcifera.*

* This may be readily understood by comparing my monograph of the Arcifera, Journ. Ac. Nat. Sci. Phil., 1866, with Duges work, or Gegenbaur & Parker's memoirs on the shoulder girdle.

Objection.—It may be objected by those who have observed some of these developmental relations, that they are exhibited by certain single structures only, and not by whole organisms. These objectors must not forget that the distinctions of those groups, which alone we have in one geological period in a relation of near affinity, exist in *single characters only;* and that it is therefore infinitely probable that the higher groups, when we come to know their representatives with the same completeness, will prove to be separated by single characters of difference also.

3. The following table is here introduced to illustrate the relations of groups higher than the preceding. This is largely measured by the circulatory system, not only as to the class relations, but also as regards orders. In its less central portions it is, however, definitive of families at times.* [The reader is here referred to the table commencing on p. 256.]

If the reader will compare the history of the development of vertebrates of any class or order, as those of Teleosts and the lizard by Lereboullet, of the snake and tortoise by Rathke and Agassiz, and of the bird and mammal by Von Baer, he will find the most complete examples of the *inexact parallelism* of the lower types with the embryonic stages of the higher. A few points are selected as examples, from the histories included in a few of the columns of the table, and given at its end.

Similar parallels may be found to exist in the most beautiful manner between the adult anatomy and structure of the urogenital apparatus within each class of the series taken separately, as indicating ordinal relationship. This department is, however, omitted for the present.

As an example of the homologies derivable from the circulatory system, and of the use of the preceding table, I give the following relations between the types of the origins of the aorta.†

The single ventricle of Teleostei is no doubt homologous with that of Lepidosteus, and that of Lepidosiren. The *arteria vesicæ natatoriæ,* which is the homologue of the *A. pulmonalis* of air breathers, issues in Lepidosteus from the last *vena branchialis,* thus receiving aërated blood from the gills In Lepidosiren it issues from the point of junction of two gilless and two gill-bearing *venæ branchiales,* thus receiving mixed blue and red blood, or blue blood altogether, when the branchiæ are not in functional activity. In Proteus it issues from the last vena branchialis, where it receives the *ductus botalli* of the preceding vein, which, when the gill is inactive, becomes a gilless aorta-bow, which brings it only carbonized blood, which it readily aërates in the swim bladder, now become a lung. The ventricle is homologous with the preceding. In Salamanders, where the substitution of the accessory gill arches by the *ductus botalli,* converts the *arteriæ* and *venæ branchiales* into "aorta-bows," the *A. pulmonalis* is given off from the posterior bow, and receives henceforth mixed blood. In the Anura the origin is the same but nearer the heart. In Gymnophidia it approaches the heart so far as to issue from the extremity of the bulbus arteriosus, which is now divided by an incomplete septum, one half conveying blood to the *aorta roots,* and the other to the *A. pulmonalis.* This septum was already preceded by a longitudinal valve with free margin in the Anura! As if to meet the coming event, a trace of ventricular septum appears at the apex within. There can now be no question of the homology of the ventricles of the gar, and of the Cæcilia. But we have next the true Reptilia. The Bulbus arteriosus is split externally, as it already was internally, but it is first represented in most Tortoises by an adherent portion, one-

* This sketch is not nearly complete, but is published in hopes of its being useful to students. It is compiled from the works of Meckel, Rathke, Barkow, Müller, Hyrtl, Brücke, Stannius and others, in connection with numerous dissections.

† Professor Agassiz (Contrib. Nat. Hist. U. S., I 285) states that the ventricle of the Testudinata "is not any more identical with the one ventricle of fishes, than with the two ventricles of warm blooded vertebrata; for in fishes we find only one vessel, the aorta, arising from it, while in Turtles both the aorta and arteria pulmonalis start together from it." We think this statement, which, if true, is destructive to the asserted homologies of the circulatory system, cannot be substantiated, for the reasons above given.

half being the now, to this point, independent *arteria pulmonalis* and the other the nearly split aorta roots. There can, I think, be little question of the exactitude of the homology throughout.

It is no less certain that the Salamander* fulfils in its development the different stages to its permanent one, and is *identical* in each stage, in *respect to this point*, with the orders it represents at the time. This is true even of the long period during which it bears the long branchial appendages and contained arteries and veins which are not found in fishes; it is then like the Protopterus, which has hyoid venous arches and appendages of those arches at the same time. The Tortoise † and Tropidonotus, ‡ are also identical in their successive stages with the types already enumerated. the external or appendicular branchial vessels being omitted as belonging to the special serial development of the line of air-breathing Anallantoidans. The division of the bulbus arteriosus into three instead of two may indicate a case of *inexact parallelism*, but on the other hand it may be that the pulmonary partition is completed a little before the aorta-root partition, thus passing through the Batrachian permanent type. For explanations of inexactitude see under Part II. No doubt the Batrachian type of bulbus arteriosus is passed by many serpents less extreme and specialized than the Tropidonotus.

The aortic and pulmonary divisions of the bulbus in the Cæcilia are not laterally placed, but one is dorsal and the other ventral, the one passing a little spirally to the right of the other. So the pulmonary division of the bulbus turns over to the right in the Anura. When the septum of the true reptiles appears it rises on the anterior wall of the ventricle till it is seen in Eunectes to meet the partition between the *arteria pulmonalis* and *aorta-roots*, and we have at once the right and left ventricles of the bird and mammal structurally and functionally. Thus are the two ventricles of man the same as the one ventricle of the fish, merely divided by a septum.§

In the fissure of the aortic bulbus in the reptiles a spiral turn is again given, and in Testudo the one aorta-root issues behind the other. In the Crocodile the turn is still greater, and the right aorta-root issues to the left of the left root, and vice versa. In the birds we have lost the left root, and parallelism ceases with this change. In the mammalia the right root turns to the left, so that in the comparison of these classes the rule of Von Baer above quoted is true; no mammal at present known is identical in a fœtal stage with any fully grown bird, but with a fœtus of the same, up to a certain point. But for both classes the parallelism of those below them holds true.

But it is with the exact parallelism or identity of genera that we have to do in the present essay. That being established, the inexact parallelism between the modern representatives of higher groups, follows by a process of reduction.

δ. The extent of parallelism.

Prof. De Serres and others have stated it as their belief that the lower "branches" of the animal kingdom are identical with the undeveloped forms of the higher; i. e. that the mollusc and articulate are not merely parallel with, but the same as the lower conditions of the vertebrate. The works of various embryologists as Von Baer and Lereboullet, have shown this statement to be erroneous "and founded on false and deceptive appearances." The embryos of the four great branches of the animal kingdom appear to be distinct in essential characters. from their first appearance. But Lereboullet, who, in his prize essay, has compared with care the development of the trout, pike,

* Amblystoma. † Agassiz. ‡ Rathke.

§ Agassiz, l. c., denies the homology of the ventricles of the turtle and mammal, but it appears to me erroneously. He says: "The fact that the great blood vessels (aorta and art. pulmonalis) start together from the cavum venosum seems to prove that the two cavities in the heart of turtles, which are by no means very marked, do not correspond to the two ventricles in mammalia and birds."

	Heart sac.	*Auricles.*	*Ventricles.*	*Atrio ventric. valves.*	*Ventr. aorto-pulm., or aorto-bulbus valves.*	*Auriculo-sinous valves.*
Leptocardii	None	None	*One*, elongate	None	None	None.
Dermopteri	Pres'nt, att. to heart at *sinus & bran. trunk.*	Present. Septum none. *Externally one.*	One, oval	*Orifice* 1; two valv's. membranous; no columnæ or chordæ.	*A.* To trunc's branch'l. Two semilunar.	Double.
Hyperotreti	Open into abd'm. cav.	Poster. to ventricle.				
Hyperoarti	Clos'd in petromyzon					
Elasmobranchii	Conn by tube w. abdom. cav.	......	One trans.; (2) musc. reticul.; no column. carneæ.	" " two valves	*B.* To bulb's arterio's.	" with threads.
Plagiostomi	a. Bifurcate.					
Holocephali	b. Simple.					
Teleostei Apodes	Closed; con. w. heart by bands in murænа and some gadidæ.	Opposite ventr	One, pyramid'l; (2) "	" " two valves	Two (4 in Orthagoriscus).	" (Four in Orthagoriscus); threads not constant.
Eventognathi	......	Opposite ventr.				
Heterosomata	......	Opposite ventr.				
In general	......	Dorsal anter.				
Ganoidei	......	Dors. ant. No sept.	(2) "			
Chondrostei	Conn. w. abd. by simple duct.	......	" with vasc'lar elevat's dors'ly & con. by vessels to pericard'm.	" " two valves; w. chordæ tendineæ.	......	One, annular, split, each half w. pockets,
Holostei	......	......	One, pyriform, (3) w. trabiculæ carneæ.	......	......	Double.
Lepidosteus	......	......	......	" " ⅔ the apert'e bound'd by one valve.	None	
Polypterus	Only a deep concav. towards abd. cav.					
Dipnoi	Closed	Dors. ant. An incomplete septum.	One, pyriform	" " ; *one valve* bounded by chordæ cartilagineæ.	No semilunar	None.
Batrachia Urodela	Closed					
Proteida	......	A complete septum.	......	*Two orifices.*		
Trachystomata	Clos'd; *att by infer. 3d of post face.*	......	......	" "		
Trematodera	Closed; att. to apex in Amphiuma.	A complete septum.	......	" "		
Myctodera	......	A complete septum.				
Anura	......	A complete septum.	No rudiment'y sept.	" " approximate, small.	One at orifice of e. of the two primary div. of bulbus.	None in Pipa.
Gymnophiona	......	......	1 & 2 " 3 & (4) a rudiment. sept. fr. apex.			
Reptilia	Closed	A compl. sept. *Externally two.*	......	*Two orifices.*	*Three semil.* at ostium bulbi. ? valv. at m'th of bulb.	
Lacertilia	......	......	......	......	......	Two.
Amphisbænia						
Ophidia	......	......	Walls not thick; very coarse network in sin. arteriosus.	One. One	aor. 2 semi. 2 semi. | p. 2 semil.	Two, semilun.

Testudinata	Closed; att. by infer. 3d of post. face.	A complete sept. ..	" 1 & 2 " 3; 4,(5) walls very thick & spongy; ossiculum on anter. end, complete side of septum.	Two; the right rudimentary.	One.	2 semi.; 2 semi.; in-n'r of both on ossicu.	2; inner on ossiculum.	Two semil.
Crocodilia	" " "	A complete sept. ..	*Two*, sept. compl'te; 2 & 4 " occasion'l perforations near apex.	Two; the right muscular.	One (? or 2).	2 semi.; 2 semi.	2 semil.	"
Aves	Closed	A compl. sept. Externally slightly separated fr. ventricles.	1 " 2, musc. trebeculæ & column. carn'æ; septum convex into right ventr.	Two; right larg'r, musc.	Two.	3 semil.	3 "	" inferior = valvula eustachii.
Cursores Apteryx	....	....	....	Chordæ tendineæ sinistræ.				
Mammalia	Closed	A complete septum.	1 & 2 " walls more compact.	3 ("tricuspid").	3 ("mitral").	" "	3 "	One = v. eustachii; rudimentary.
Implacentialia	....	Right, small	....	All membranous & bound by chordæ tendineæ; in monotremata; two in mitral, w. are att. to columnæ carneæ.				
Monotremata ...	....	....	....					
Marsupialia	....	No fossa ovalis on septum.						
Placentialia								
Halicore	....	....	Separated for some length.					

	Post-ventricular cavity.	*Arteriæ branchiales.*	*Venæ branchiales.*	*Arteria pulmonalis.*	*Vena pulmonalis. At first v. vesicæ pneum*	*Art. subclaviæ.*
Leptocardii	I. Series of lateral alternating bulbilli.	One *from* each *bulbillus.*	*Enter aorta direct;* All separate.	None (no swim-	bladder). None.	None.
Dermopteri	II. Truncus branchialis communis.	[A pair of ant. or false aor. bows; rudimentary in Hyperotreti.] *Fr. truncus;* 7 usually anter. somet. united, = bifurca. of truncus.	? united.	"................	....	"
Elasmobranchii	III. Bulbus aterio-sus w. musc. coat & 2 or more rows valves.	*Fr. truncus.* 5; fr. bulbus: 2 ant. united.	Anterior united ...	"		
Plagiostomi.						
Squali	....	Three post. sepa'te.				
Rajæ	....	Three post. united.	....	....	....	From origin of aort.
Pristes	....	Three post. united.				
Holocephali.						

	Post-ventricular cavity.	*Arteriæ branchiales.*	*Venæ branchiales.*	*Arteria pulmonalis.*	*Vena pulmonalis. At first v. vesicæ pneum.*	*Art. subclaviæ.*
Teleostei	IV. Bulbus arter. without musc. walls, no valves. (exc. Butyrinus.)	*Fr. truncus* which is fr. bulbus; 4 on each side, (anter. wanting).	*Enter aort* by a.roots, *i. e.*, by poster. trunks of circulus cephalicus, or direct when poster. to completion of circulus.	? Empties into portal, hepatic or cardinal vein.	Into vena hemiazygia or from vertebralis posterior; often subdivides into rete, and unites.	Origin often unsymmetri'l. Comm. trunk of anter. venæ branchiales Esox.
Apodes Murænophis		a. Two ant. sepa'te.				
Nematogn. Saccobranchus	....	b. Two ant. united. 1. All to gills. * Post. sending art. to air sac, = branch. operc.				From origin of aort.; Perca.
Class in general.	....	** Post. not send'ng art. to air sac, =bran. operc.	....	....	Into v. portæ in Lota.	Fr. each aorta root; Gadus.
Ap. Symbranchus Monopterus .	....	2 4th no gill, ∴= aor. bow.	....	....	....	From origin of aorta, then dividing into 3; one branchialis, one *lateralis!* one dorsal. ascend.
Amphipnous ..	....	Five art. bran. ant. to air sac. 1st & 4th no gills; vein from air sac to 4th.				
Ganoidea	V. Bulbus arter. w. musc. walls and 3 or very many rows valv.	*Fr. truncus*, fr. bulbus; 5 on e. side; ant. is an opercular pseudo-branch'l and revehent art.	*Enter aorta* direct.			
Chondrostei.		1. Rising from 2d art. branch.				
Spatularia	....	a. 1st true branch'l to 2d gill; 2d and 3d united.				
Accipenser	....	b. 1st true br. art. to 1st gill.				
Holostei	....	2. Rising fr. & = ant. fork of truncus; 1st true art. br. to 1st gill.				
Lepidosteus ...	....	....	....	....	....	Very large; fr. aort., poster. to entrance of 3d vena. branch. communis.
Polypterus	....	....	....	From last vena branchialis.	*Enters hepatic vein.*	
Amia	....	Four on e. side fr. truncus, 2 ant. unit'd.	....	? Empt. into vena cava ascend.	" vena cava ascendens.	
Dipnoi	VI. Bulb. arter. spiral, w. two elongate spir. valves.	*Fr.* 2 *primary heads* of *bulbus*; 5 on e. side; 1st rising fr. 2d; 2d & 3 gilless; 5th to 2 gills.	*Enter two aorta-roots;* two become parts of aorta-bows.	From confluence of v. branchiales & aorta bows.	*Enters auricu'a sinistra*, pass's vena cava & sinus & has valv. tuberc. at ostium.	
Protopterus ...	....	a. Trunc. to ext'l gills.				
Lepidosiren ...	....	b. No " " "				

Batrachia	VII. Bulb. not muscular; a longitud. v.	....	....	....	"	
Urodela.						
Proteida	Bulb. narrow at beginning.	Prim'y div. of bulb. =2 trunc. br. comm.: 3 Art. br. on each side, 2 post. united first.	Are both ven. branch and aorta-bows, from existence of 3 duct. botalli.	From poster. vena branch.	....	From aorta.
Trachystomata	Bulb. twisted; one longit. elevat. (= septum) w. six grooves corr. to art. branch.	a, b. *From bulbus;* 3 on each side.	No ductus botalli.	" " "		
Trematodera	....	Become *aorta bows* from want of gills. Four; ant. & post. conn. by duct's botalli; 2 median = aorta root.		Fr. poster. aort. bow.		
Myctodera	....	Four; ant. & post. conn. by duct's botalli; 2 median = aorta root and with one ostium into bulbus art.		" " " giving branch's to œsoph and pericardium.	....	" "
Anura	Contain. longit. septum w. a free edge: each half prolonged into 1 primary div. of bulbus.	Three; no ductus botalli; median = aort. root.		Fr. poster. aort. bow sends off ramus cutaneus in front of shoulder to back.		
Gymnophiona	Elongate; div. anterior. into dorsal & ventral cham.; valves at origin.	One; by obliteration of 1st and last, *aorta roots* only remain.		Fr. dorsal chamber of *bulbus arteriosus.*		
Reptilia	VIII. No proper bulbus; the aorta roots and pulm. art. adherent.			From cavum venosum =(dextrum) of ventricle.		
Lacertilia in gen.	....	Two aort. bows, fr comm. ostium fr. cavum arteriosum (sinistrum).		....	"	From trun. subclav. comm.; fr. right aorta root.
Varanidæ and Tupinambis	....	One aorta bow, =aorta root. " "				
Amphisbænia	....	*One* " " " "				
Ophidia	....	" " "				
Testudinata	Aorta roots and art. pulm. adherent and surr. by ring of musc. tissue at origins.			....	"	Each fr. innommin., fr. trun. innom. comm. from right aorta root.
Crocodilia	Aorta roots and pulm. art. adherent; right aorta root from left ventr., left from right, commun. by a foramen above valves.			From right ventricle; attached.	"	Dextra fr. right aort. root; sinist. fr. innom.
Aves	IX. Right aorta root (fr. left ventr.) only =aorta.			Do. Free.	"	Sinistra very large; given from aorta immediately; first as innominata.
Mammalia	X. Right aorta root (*i. e.*, aorta) turning over the left bronchus to the left side.			Do. "	"	Dextra issues later; sometimes an innominata.

	Carotides.	*Cerebrales.*	*Ophthalmicæ.*	*Vertebrales.*	*Intercostales.*
Leptocardii.					
Dermopteri					
Hyperotreti ...	1. Each carot. communis a continuation of a vessel connecting venæ branch. parallel to aorta. Divide to *c. ext.* and *int.* behind skull; *intern.* unite at base of cranium and receive vertebralis.	Median from conjunction of carot. intern.	......	Median, a continuation of aorta.	
Hyperoarti ...	2. Carot. communis from anter. vena-branchialis. Carot. intern. do not unite.				
Elasmobranchii ...	3. No c. communis; posterior from 1st vena branch. or from united anterior ven. branchiales; united beneath cranium.	......	......	......	From aorta direct.
Plagiostomi ...	(a.) Anter. carot. from pseudobranchia, *i. e.*, vena branch. prima.	......	Fr. pseudo-branchiæ		
Holocephali ...	b. Ant. ("poster.?") from ven. branch. secunda.	......	Fr. carotis anterior.		
Teleostei ...	4. C. commun. from circulus cephalicus.	......	Fr. pseudo-branch., ends in "glandula choroidalis."	......	Often break into retes.
Ganoidei ...	......	......	Fr. pseudo-branch.		
Chondrostei ...	As in 3 (a).				
Holostei.					
Lepidosteus .	5. Anter. carot. from aorta, anter. to entr. of 3d pair of v. branchiales; poster. carot. sending no branch to brain.	From near origin of aorta.	Fr. pseudo-branch.		
Dipnoi ...	As in 3 (b).	......	Fr. carotis anterior.		
Batrachia.					
Proteida ...	As in 3: (c), the ? anter. ("post.") carot. from aorta bow.				
Trachystomata					
Trematodera ..	6.(a) Carotis comm. from anter. aorta-bow. No glandula carotica.				
Myctodera ...	6 (b). A glandula carotica.	......	From aorta-root (most anteriorly).	......	In pairs from aorta.
Anura ...	6 (b). Carot. extern. cont. 1st as max. intern. and then opthalm.	......	From carot. extern.	......	Small; from an "a. supravertebralis" run'g. ab. diapoph. on each side, ?homolog. w. inlercostal. prim.?
Gymnophiona .	7. Carotis commun. from anter. curve of each aorta root.				
Reptilia ...	A. Carotis poster. connected w. its fellow by ramus communicans behind foramen magn.	B. Continuation of carotis interna. Circulus willisii compl'te	From A. facialis (= carot. ext.) more or less connected with cerebr. anter.		

Ophidia	8. Both. carot. commun. from right aorta-root direct. (a). Entirely separate. (b). Running together after issuing from a short tr. carot. impar. (c). Left carot. comm. rudimentary. (d). " " " absent.	....	....	One from trunc. arter. dexter.; divides; each half running beneath diapophyses & entering ramus com. of carotis internal; through this to basilaris.	Fr. trunc. art. dexter., fr. comm. truncs fr. aorta.
Peropoda, Angiostomata	....	....	Fr. cerebralis anter.	In Rhinophis, strong, like a cont. of aorta.	
Amphisbænia	7. Each carot. comm. from anter. part of each aorta-root.		From?		
Lacertilia	....	....	Fr. art. facialis....	Two from axillaris; each entering spinal canal and forming a supraspin. thro' those to basilaris.	Fr. sublaviæ, trunc. arterios. dexter, and aorta.
Varanidæ and Tupinambis	As in 7.				
In general	9. Each carot. comm. a continuation of cardiac extrem. of anter. aorta bow.				
Testudinata	10. Each c. c. from innominata; fr. common innom.; from right aorta root.	....	Fr. cerebralis anter.	" " " also connect w. cervicalis descend. from carot. extern.	In body and tail fr. an intercostal, prima continued fr. subcl. to iliaca, the "intern. recurrens." In neck from ram. comm. fr. carot. ext. to subclav.
Crocodilia	11 (a). Car. comm. fr. truncus carot. impar, w. is from left innom.; or (b) c. com., each from an innom.; all from right aorta-root, or as in 10.				
Aves	B. *No occip. union of carotides posteriores*: one or both c. comm. run on sides of neck.	Fr. a union or communication of carot. int. w.=ramus com. of cerebralis anter. of mamm.; circ. willisii is abbreviated anteriorly. Cer. anter. goes to orbit or olfactory reg. Poster. to basilaris & spinalis anter.	External branch of carotis internus.	B. *Traverses cervical canal.* 1. Not forming basilaris; conn. w. occipitalis. From truncus or carot. communis of its side.	Usually from aorta.
Insessores, Passeres, Zygodactyli 3/4, Syndactyli 1/2	(a). Car. comm. fr. tr. carotic. impar. fr. left innom. [vid. on Pitta sp. Tidjschr, Neederl. Ind.]				
Synactyli, Zygodactyli cuculus and in general, Cursores, exc. Rhea, Natatores	(b). Carot comm. from each innom. from aorta.	....	....	....	In Gallus, a few fr. intercost. prima; in Ciconia last from Epigastr., rest fr. prima. In Anas 5 or 6 from intercost. prima, 3 or 4 fr. vess. connect. in. terc. prima w. aorta.
Natatores Podiceps	As (a)........	....	....	....	

	Carotides.	*Cerebrales.*	*Ophthalmicæ.*	*Vertebrales.*	*Intercostales.*
Cursores Botaurus	As in 11 (b)!				
" Phœnicopterus	(c). Carot. comm. from right innom. from aorta.				
Mammalia......	......	Via canal carot., or foramen jugulare. Ramus communic. betw. cerebr. anter. C. willisii alw'ys pres'nt. Somet. ramus comm. is between art. corporis callosi.			
Implacentialia......					
Monotremata, Phascolomys & Phascolarctus	d. One car. comm. fr. innom. dextra fr. aorta; one from aorta direct.			3. Forming basilar.	
Marsupialia......	c. Both c. c. fr. innom. dextr.; fr. aorta.				
Placent. Rodentia...	e. " " " " " except Muridæ, Cricetus, Dipus Meriones, which exhibit d.	Fr. carot. ext. via a. opthalmic and foram. opt. in some Caviidæ; via max. intern. and foram. lac. anter. Hystrix.	Sciurus=intern. br. of ant. cerebr. (br. ext. leaves cran. and joins max. interna). Arctomys same, without extern. branch.	In Mustela fr. tr. communis vertebr. fr. aorta.	In Mustela, anterior fr. tr. com. verteb.
Proboscidia......	f. From truncus car. impar.; fr. aorta direct; Elephas.				
Artiodactyla......	g. From truncus car. impar.; from right innom. Sus.	From carot. ext. via max. intern. in Ovis.	Sus; from max. int. =carot. ext.	2. Connected with occipitalis; w. basilar by small branches.	
Perissodactyla......	h. Each c. com. from right innom.; from innom. communis.				
Equus......	i. From tr. carot. impar.; from r. innom.; from innom. communis.	......	......	As in 1	
Cetacea, Halicore	As e.	......	......	As in 3	
Phocæna	As i.				
Delphinidæ	k. No carot. comm. Carot. intern. and ext. fr. innom.	......	......	4. Confluent w. occipital. and cervic. ascend. = "cervico-occip."	5. Anter. fr. mammar. intern.
Carnivora......	As in e, except Phocidæ=d., also Brachypus, Dasypus and Cyclothorus.	......	......	As in 2 in Canis, Mustela.	
Edentata......					
Insectivora, Sorex	As in e.	& in some rodents, enter'g via stapes!!			
Talpa	As in l.				
Erinaceus	As in d.				
Cheiroptera......	l. C. comm. fr. each innom.; fr. aorta.				
Quadrumana......	As in d.				
Homo......	......	......	......	......	1st fr. subcl., rest of dors. div. from aorta.

	A. cœliaca.	*A. mesenterica.*	*A. iliaca.*	*Sinus venosus.*	*Venæ anonymæ.*	*v. Hemiazygeæ or Vertebrales poster.*
Leptocardi						
Dermopteri	From aorta.	....	....	a. Present; contractile.		I. Supravertebral. (a continuation of caudalis):
Hyperoptreti	....	....	....	....	I. One on left side ...	On left side only.
Hyperoarti	....	....	....	....	II. Two, called "Trunci transversi." Receive subclaviæ, vertebrales and hemiazygeæ.	On both; equally large. (In Petromyzon *conn. w. subvert.* sac.)
Elasmobranchii	" Includes Mesenterica anterior.	A posterior only.	....	Present	....	II. Subvertebral. a. Emptying into anonyma.
Plagiostomi						
Squali	In Lamna sp. developes retes mirabiles near diaphragm.					* Of equal size. Receive renales revehentes.
Pristes						
Rajæ	[Mesent. ant. separate	....	....	....	....	Conn. w. a subvert. sac.
Holocephali						
Teleostei	....	....	....	Present	....	** The dexter larger.
	[In Thynnus a subhepatic rete [In Gadus g. from aorta root.					
Plectognathi ...	....	....	....	....	....	* Of equal size (Diodon).
Ganoidei						
Chondrostei	....	....	....	....	....	* Of equal size; breaking into spongy masses or retes in Accipenser.
Holostei						
Dipnoi	....	....	....	Present.		
Batrachia	....	....	....	"		
Proteida	" Gastrica separate from aorta.	Many, small.	Symmetrical.			
Trachystomata						
Trematodera						
Myctodera	" Gastrica indepen.	Two, anter. & post.	Give femoralis and epigastrica.	....	....	Do not receive renal. revehs.
Anura	From left a. root, including both mesenterics.	....	Rise at mid. of coccyx			aa. Emptying into iliaca. Two, equal.
Gymnophiona						
Reptilia	....	....	....	Present.		

	A. cœliaca.	*A. mesenterica.*	*A. iliaca.*	*Sinus venosus.*	*Venal anonymæ.*	*v. Hemiazygeæ or Vertebrales poster.*
Ophidia ...	" Four gastricæ.	" " "	...	Continuation of anonyma dextra and v. cava inf.	An. sinistra the continuation of jugularis only.	a. Emptying into Anonyma. One median.
Amphisbænia						
Lacertilia.						
(Psammosaurus	From aorta.)	United, fr. left a. rt.				
Testudinata ...	A gastroepiploica instead.	One, fr. left a. root.	Hypogastric & cruralis separate.	a. Present ...	...	III. Above heads of ribs conn. iliaca and anonymæ.
Crocodilia ...	One, incl. gastr. and mesenterica; fr. left aorta root.	...	...	? ...	...	II.?
Aves ...	" Excl. mesent.; fr. abdom. aorta.	Super. fr. aorta; inf. fr. caudalis s. sacra-media.	1. *None*; cruralis & hyp'g. separate; latter fr. caud. s. sacra med., not giving ischiadica, w. rises from aorta & is larger th cruralis.	aa. Absent ...	Coronaria enters an. sinistr. anonym. from union of vertebrales first, then jugularis, then subclavia.	III. a. Each unites w. ant. verteb. Comm. trunk then ent. anonyma.
Apteryx ...	" Fr. ab. diaphr'm.	Sup. fr. ab. diaphr.				
Mammalia ...	One fr. aorta.	Independent. ...	Cruralis and hypog. mostly separate.	aa ...	...	(II.) aa Enter v. cava descend. or anter., or the two anonym.
Implacentialia ...	...	Infer. wanting. ...	Ischiadicæ fr. aorta [(larger than cruralis) =hypog. of Meckel?]	...	" ...	"
Monotremata ...						
Marsupialia ...						" 1. Two, equal.
Placentialia ...	...	Infer. present. ...	Ischiad. fr. hypogastr., *exc.*?			
Rodentia ...	...	Super. wanting in Cavia.				" Except?
Proboscidia ...	...	...	...	...	Elephas ...	2. One, or dextra much larger.
Perissodactyla ...	...	...	...	...	III. An. sinist. enters dextra (coronaria ent. comm. tr.) Conn. by a cross trunk in Lepus.	"
Solidungula						"
Cetacea ...	...	...	Wanting in cruralis. Hyp'g. ending in retes in Manatus.	...	...	IV. a. Run in spinal canal; emerge, unite and enter anon. dext.
Carnivora ...	...	...	...	...	...	II.
Edentata						
Insectivora ...	...	Talpa, super. emptying in coeliaca.	...	...	Erinaceus & Sorex as II.	" In Talpa, 2, equal; one entering right atrium.
Cheiroptera ...	...	Vespertilio, super. emptying in coeliaca.	...	...	Same as in II ...	" The right much larger, empt. into v. cav. desc.
Quadrumana ...	...	...	2. *Present.*			

	Vena caudalis.	(V. vertebrales et) V. Jugularis (extern.)	V. cava ascendens.	V. iliaca.	V. portæ.	V. hepaticæ.
Leptocardii					Contractile rythmically.	
Dermopteri	A. Single. a. Prolonged directly into hemiazygeæ.	A. *Does not take blood from brain.* Single (enters sinus venosus); on l'ft side.	None		Fr. aliment. canal and organs.	I. Two or three; emp. into sinus venosus.
Hyperotreti		(a). Verteb. sinister only (fr. skull).			(a). Contr. rythm'y. Receives veins of abd. wall. Has a sac-like expansion.	
Hyperoarti		(b). Two vertebral (from skull), mostly receive subclavia.			(b). Not contractile.	
Elasmobranchii		I. Double; one each side. Verteb. take blood from skull.	"			
Plagiostomi	Common intercost. trunks sub-divided in kidneys.				Concealed in margin of spiral valve.	
Rajæ					Finally single.	Exhibit sinuses.
Holocephali						
Teleostei	b. Continued as renalis advehens; as renalis, receives com. trunks of 2 or 4 intercostals.	I, or single (entering sin.) in Cottus, Thynnus; often dilate into sinuses.	" [present in Perca, from spermatica and pneumatica; does not ramify in liver.]		Often rec. veins of walls of abdomen (homolog. of epigastrica). Often tr. to liver are very numerous, esp. Eventognathi.	II. Mostly one; often two; rarely three.
Ganoidea Chondrostei			None.			
Polyodon					One trunk.	
Accipenser						One.
Holostei.						
Dipnoi	Divides to join renalis advehens.					
Batrachia		B. *Takes blood fr. brain.*	A. Present; formed fr. renal. revehentes. *Passes through liver.*	A. *Is a renal. adveh.*	From a median abdominalis anter., or epigastrica.	a. Empty into v. cava ascend.
Trachystomata						
Proteida						
Myctodera	c. Forks, each fork uniting w. cruralis.			1 a. From fork of caudalis & cruralis.		
Anura	None; crural.=renalis adv.			a. Forks of caudal. =a transv. anastomosis.	An origin fr. each iliaca.	
Gymnophiona						
Reptilia						

	Vena caudalis.	(V. vertebralis et) V. Jugularis (extern.)	V. cava ascendens.	V. iliaca.	V. portæ.	V. hepaticæ.
Ophidia	......	(I.) Dexter only into anonyma.	......	From fork of caud. (=?hypogas.) only on left; on right from caudalis and abdom. impar.	Is continuation of v. abdominalis w. rec. v. of aliment. canal & accom. organs; contains a long spiral valve; originates fr. iliaca dextra only.	
Amphisbænia.						
Lacertilia	......	......	......	......	An origin fr. each iliaca.	
Testudinata	B. Double; ab. diapophyses.	Fr. cranial sinuses.	......	Fr. caud. (*hypogas.?*) and cruralis.	Three; 1st from two symmet. v. abd. ant., 2 fr. do. abd. post., 3d fr. v. tract. intestinal.	b. Empty into atrium dextrum.
Crocodilia	A. Single; hypaxonic.	......	Formed from renal. revehs. and branches of iliacæ.	AA. *Is not renalis adv.* 1. Sends off large ren. adv., takes up ren. rev. [Previously conn. by anast.] continued as abd. anter.	Three; an abd. fr. each side fr. iliaca, & v. of aliment. canal & organs.	a.
Aves	Two, unite and continue into V. portæ.	A. Do not receive bl. fr. brain, or a small branch only. Not near course of carotids; an anastomosis nr. head; ∴ right is larger, or alone (as in Picidæ sp.) Subst. by verteb. Run in cervic. canal.	A. Fr. iliacæ; receiv's abdom. ant. after hepaticæ.	2. Fr. hypogas. and crur. [hypogas. a continuation of lat. fk. of common caudalis; as such perforates kidney.]	Comm. trunk from united caud., taking up v. tractus intest.; [∴ =mesenterica.] or former ? is a right v. port., the latter one or more v. p. sinistræ.	a. Usually 2, dext. & sinist. in liver.
Apteryx	......	......	......	Not imb. in kidney.		
Mammalia	Ent. v. cava ascend.	B. Take blood from brain; verteb. small, in cervic. canal.	B. Through groove of liver only.	2. No part. of hypogas. passes thr. kidn.	From splenic and sup. mesenter. only.	a.
Implacentialia.						
Placentialia.						
Rodentia and Proboscidia.						
Artiodactyla	......	......	......	......	Semilunar valves in Bos.	
Perissodactyla	......	......	......	......	Semilunar valves in Equus.	
Cetacea	In many into right iliaca.	......	With expansions in most divers.			
Carnivora	......	......	In Phoca enclosed by contractile muscular ring at diaph'm.			
Edentata and Insectivora.						
Cheiroptera.						
Quadrumana	......	C. Take no blood fr. brain; jugular. intern. do this.				

and perch of the Teleosts, with that of a Lacerta among reptiles, has failed to point out characters by which the embryos of the two vertebrate classes essentially differ, for a considerable period. It is true, that as each and all of the species belong to widely different generic series, parallelism is of the kind to be called *inexact* or *remote*. But enough is known of embryology and palæontology to render it extremely probable that the historic predecessors of the types whose embryology Lereboullet studied, formed a series of parallels of the kind termed in this essay *exact*.

Lereboullet states that a certain difference exists between the eggs of the fishes and those of the Lacerta. This is for us merely stating that the parents of the embryos differ, a fact which no one will contest. The same may be said of the elevated or depressed character of the surface of the vitellus on which the embryo reposes.

Secondly, after the appearance of the embryo the Lacerta is furnished with the amnios and allantois, the Teliost not. This is certainly neither a generic, ordinal nor class character of the adult, for it is but temporary; therefore in generic, ordinal and class characters the embryos of the Teliost and Reptile are still identical. It is a physiological character and not morphological, and therefore far the less likely to be a permanent one, even in embryos, under changed circumstances. The female of one of the species of Trachycephalus inverts the skin of the back at one season of the year to receive her eggs, because she cannot lay them in the water; the other species of the genus do not. The next genus in direct morphological line possesses a single species whose female does the same for the same reason; but the relations of these species and genera are zoologically the same as though this modification did not occur. Many such instances will occur to many naturalists. It is not pretended that they are as important as the presence of the allantois; but they constitute a character no doubt similar in kind, and entirely at the service of the needs of the great system of morphological succession. The same may be said of the vascular area of the Reptile.

Lereboullet concludes his summary of the differences between the Teliost and Reptile, up to the period of completion of the heart, by saying "It is easy to perceive that all these differences, however important they may appear, are constituted by the accessory organs of the embryo, and do not modify the development of the latter, which progresses in reality exactly as in the fishes." He says the same previously, as to the relation of the same to the bird and mammal.

We have then in the embryos of the lower vertebrates at a certain time in the history of each, an "*exact parallelism*" or *identity* with the embryonic condition of the type which progresses to the next degree beyond it, and of all the other types which progress successively to more distant extremes.

We have, however, so far, every reason to suppose that the embryos of the other branches of animals never present an exact parallelism with those of the vertebrata.

The embryo of the fish and that of the reptile and mammal may be said to be generically if not specifically identical up to the point where preparation for the aerial respiration of the latter appears. They each take different lines at this point. The fish diverges from the course of the reptile and proceeds to a different goal; the shark does the same, but proceeds a shorter distance, while the Dermopter scarcely leaves the point of departure. No doubt there have been types which never left this point, and *whose plan* or *circulatory system* is identical with that of the embryo Reptile and Mammal. *Such a type was only generically different from the reptile or mammal which had only taken the succeeding step*, provided other structures were not super-added.

By comparing the development of types of different classes in certain features which are only ordinal or generic in meaning, very erroneous conclusions may be reached by the inexact student, as to the want of parallelism of classes to each other. Thus Rathke says of the development of the eye of the Tropi-

donotus at a certain period, that it is far in advance of that of the mammal at the same stage. Here, says the objector, is a case where their parallelisms do not coincide; the mammal is really similar to a younger stage of the Reptile.

But, in fact, the size of the eye is but a generic or family character; if the development of the lemur had been compared with the snake, the mammal would have been found to be in advance; if the mole, much farther behind. If the snake selected were the purblind Atractaspis, almost any mammal would have been in advance; if, on the other hand, the great eyed Dipsas, but few mammalia would have been parallel to it.

In a word, to find *exact parallelism* it is necessary to examine the closest allies.

It is also of first importance to distinguish between the *existence* of generic or higher characters, and their condition under various circumstances of *individual life*. If a fœtal or larval character be conserved through the adult life of a type, it will be of course adapted to the functions of mature age. Thus the undeveloped character of the horns of the genus of deer, Rusa, are not accompanied with the marks of individual youth of the corresponding stage of Cervus; its individuals are fully grown and *functionally* perfect. The species of Hyla are not small and incapable of self preservation and reproduction, as is the corresponding stage of Trachycephalus; they are functionally developed. The student need not be surprised, then, if, when identity or exact parallelism is asserted, he finds some differences dependent on age and adaptation, for if he be an anatomist he need not be informed that a morphological relation constitutes types what they are, not a physiological.

II. *Of retardation and acceleration in generic characters.*

First. *Of adult metamorphosis.*

The question has necessarily arisen—have these remarkable relations between genera resulted from an arrangement of distinct generations according to a permanent scale of harmony, or have the same genetic series of individuals been made to assume the different positions, at the same or different periods of the earth's history.*

Prof. Marcel de Serres proposed the theory of repressions of development to account for the existence of the lower groups of animals *as now existing*, an error easily exposed, as has been done by Lereboullet in his various important embryological writings. But little observation is sufficient to prove that a mammal is not a shark where it has five gill arches or aorta bows, nor a batrachian where it has three, or a reptile where it has the two aorta-roots. This has been already sufficiently pointed out by Von Baer, who says there is "Kein Rede," of such a theory as was afterwards proposed by de Serres. Thus are true the rules propounded by this author.† 3. "Each embryo of a given animal type, instead of passing through the other given animal found, diverges still more from it." 4. "In the basis, therefore, the embryo of a higher animal type is never identical with an inferior type, but with the embryo only of the latter"

* Some naturalists seem to imagine that the demonstration of the existence of intermediate types is only necessary to establish a developmental hypothesis. Thus Dr. Dohrn (Ann. Magaz. N. Hist., 1868), writing of his discovery of that most interesting genus Eugereon, which combines characters of Neuroptera with those of Hemiptera, does not hesitate to say that it proves the truth of Darwin's theory. Now it appears to me that a demonstration of the existence of a regularly graduated succession of types from the monad to man, would be only the m nor of a syllogism without its major, in evidence for development, so long as the proof of transition of one step into another is wanting; and the idea that such a discovery could establish a developmental theory is entirely unfounded. Indeed the reasoning in which some indulge—if we dare so call the spurious article—based on this premise alone, is unworthy of science. The successional relation of types, though a most important element in our argument, has been long known to many who give no sanction to the idea of development.

† Entwickelungsgeschichte, 224.

I think that I have already made some progress in proving that the near or true generic relationship is one of absolute developmental repression or advance. Palæontology shows that families and orders, as now existing, were preceded in time by groups which are synthetic or comprehensive, combining the common characters of modern generic series. This process of synthesis must, it is obvious, if continued, result in the near approximation of the single representatives of the now numerous and diverse groups. There is every reason to believe that a backward view through time will show this to have prevailed throughout the vertebrata and other branches, as we already can in part prove. And I have no doubt that the synthetic types, which represent modern orders, have existed in a generic relationship subordinate to the plan of the synthetic class, and that the latter have existed as genera only, of the type of the great branch. This is not ideal. We only have to look to our extinct ganoids, Archegosaurs, Labyrinthodonts, Compsognathus, Archæopteryx, Ornithorhynchus, etc., to realize these facts.

The first genera then formed a scale of which the members were identical with the undeveloped stages of the highest, and each to each according to their position.

Such a series of antitypic groups having been thus established, our present knowledge will only permit us to suppose that the resulting and now existing kingdoms and classes of animals and plants were conceived by the Creator according to a plan of his own, according to his pleasure. That directions or lines of development towards these ends were ordained, and certain laws applied for their realization. That these laws are the before-mentioned law of RETARDATION AND ACCELERATION; and law of NATURAL SELECTION.

The first consists in a continual crowding backwards of the successive steps of individual development, so that the period of reproduction, while occurring periodically with the change of the year, falls later and later in the life history of the species, conferring upon its offspring features in advance of those possessed by its predecessors, in the line already laid down partly by a prior suppression on a higher platform, and partly as above supposed, by the special creative plan. This progressive crowding back of stages is not, however, supposed to have progressed regularly. On the contrary, in the development of all animals there are well-known periods when the most important transitions are accomplished in an incredibly short space of time, (as the passage of man through the stages of the aorta bows, and the production of limbs in Batrachia Anura;) while other transitions occupy long periods, and apparently little progress is made.

The rapid change is called metamorphosis; the intervening stages may be called larval or pupal. The most familiar examples are those which come latest in life, and hence are most easily observed, as in the insects and frogs. When, during the substationary period, the species reproduces, a constancy of type is the result; when the metamorphosis only appears at the period of reproduction a protean type is the result; when the metamorphosis is crowded back to an earlier period of life, then we have another persistent type, but a new genus of a higher grade than its predecessor.

In reviewing many examples everywhere coming under the eye of the naturalist, it is easy to perceive what would constitute a *plastic* and what a *conserved* condition of generic, or even of specific form.

As one or more periods in the life of every species is characterized by a greater rapidity of development (or metamorphosis) than the remainder, so in proportion to the approximation of such a period to the epoch of maturity or reproduction, is the offspring liable to variation. During the periods corresponding to those between the rapid metamorphoses the characters of the genus would be preserved unaltered, though the period of change would be ever approaching.

Hence the transformation of genera may have been rapid and abrupt, and the intervening periods of persistency very long; for it is ever true that the

macrocosm is a parallel or repetition of the microcosm in matter and mínd. As the devělopment of the individual, so the development of the genus. We may add—so the development of the whole of organized beings.

These metamorphoses may be fitly compared to those in the molecular constitution of matter. The force of cohesion between the atoms of a vapor steadily increases with descending temperature, and in a regular ratio, till a given point is reached, when a sudden metamorphosis to a denser, or liquid condition takes place. Nor have we reason to believe, with regard to many substances, that there is any parallel relation between the temperature and the molecular constitution before or after the metamorphosis takes place. So the temperature continuing to descend, the molecular character of the liquid remains unchanged until the *vis conservatrix* suddenly giving way at the ordained point, a solid is the result. Thus while the change is really progressing the external features remain unchanged at other than those points, which may be called *expression points.*

Now the *expression point* of a new generic type is reached when its appearance in the adult falls so far prior to the period of reproduction as to transmit it to the offspring and to their descendants, until another *expression point* of progress be reached.

Thus a developmental succession does not so obliterate the lines drawn around nature's types as to render our system ineffectual as an expression of them.

The successional acceleration or retardation in metamorphosis may be best illustrated in the cases selected above, by the following tables. These are taken, it will be remembered, from the Bufonidæ and Hylidæ as examples of "exact parallelism;" three are now added from the Ranidæ and Discoglossidæ. The case of "inexact parallelism" is that of the Scaphiopodidæ.

Whether they are cases of acceleration or retardation can only be determined by reference to the palæontology of the respective groups, or a careful comparison of times of metamorphosis. In the case of the Discoglossidæ I suspect it to be retardation, as the highest genus is extinct. The others I shall arrange with them for temporary convenience. Were I dealing with a group of Ganoids, I should imagine the process to be retardation, as this group is going out of existence. On the other hand, were they higher Oscine birds we might imagine the case to be reversed.

TABLE I.

Assumed,		Series No. 1.	No. 2.	No. 3
140th gen.	: :	Bombinator	Hyla	Epidalea.
120th gen.	: e :	Alytes*		
100th gen.	: e Pf : F	Discoglossus.		
80th gen.	: e Pf F :		Scytopis	Bufo sp.
60th gen.	: e. Pf F Ex :		Osteocephalus	Bufo sp.
40th gen.	: Pf : F Ex t			
20th gen.	Pf : ?F : Ex t .	Latonia	Trachycephalus	Peltaphryne·
1st gen.	: ? : :			

Hatched

Prefrontals meet (in series 1 and 3 only).

Lose tail.

Front ossified.

Persistence audit'y apparatus. (Series 1 only).

Exostosis.

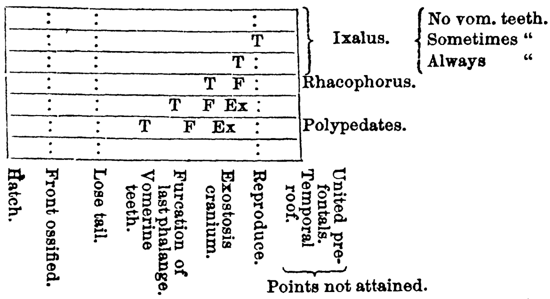
Temporal roof.

Reproduce.

Death.

* A parotoid gland of small size is added here, but is not generic as compared with Bombinator, as the latter has collections of crypts on the same region and over the body.

TABLE II.


Ixalus.
No vom. teeth.
Sometimes "
Always "
Rhacophorus.
Polypedates.
T
T F
T F Ex
Hatch.
Front ossified.
Lose tail.
Vomerine teeth.
Furcation of last phalange.
Exostosis cranium.
Reproduce.
Temporal roof.
United prefontals.
Points not attained.

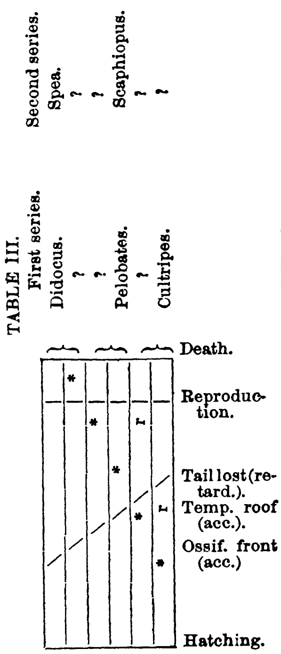


TABLE III.
First series.
Didocus.
Pelobates.
Cultripes.
Second series.
Spea.
Scaphiopus.
Death.
Reproduction.
Tail lost (retard.).
Temp. roof (acc.).
Ossif. front (acc.)
Hatching.

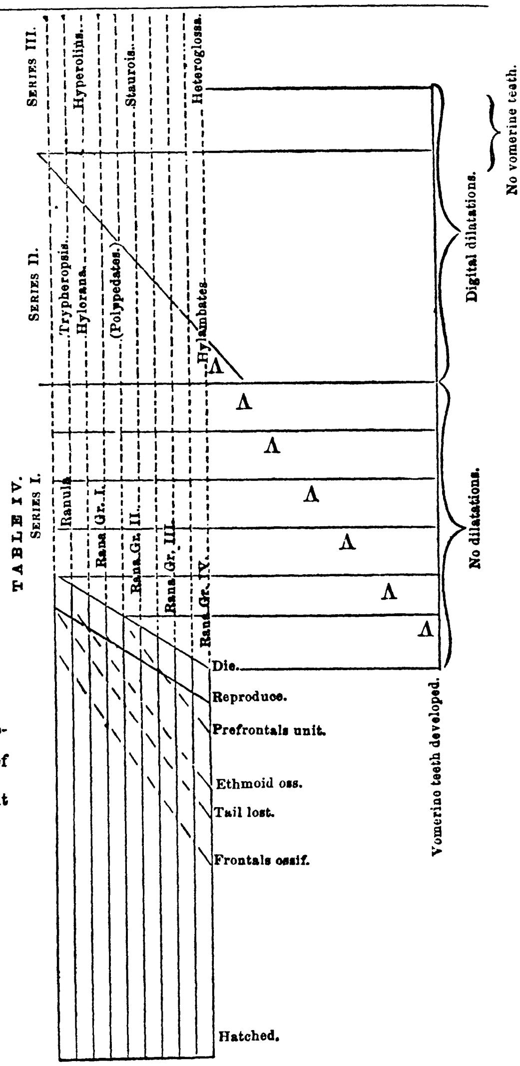


TABLE IV.
Series I.
Series II.
Series III.
Hyperolius.
Stauroia.
Heteroglossa.
Trypheropsis.
Hylorana.
(Polypedates.)
Hylambates.
Ranula.
Rana Gr. I.
Rana Gr. II.
Rana Gr. III.
Rana Gr. IV.
Die.
Reproduce.
Prefrontals unit.
Ethmoid oss.
Tail lost.
Frontals ossif.
Hatched.
Vomerine teeth developed.
No dilatations.
Digital dilatations.
No vomerine teeth.

In the preceding diagrams each horizontal column represents the life history of the individuals of each genus. The line of dots, stars, etc., represents the same developmental stage of each, as it appears earlier or later in the life of the individuals. The point of crossing the breeding period is that at which the character is rendered permanent. When the change falls on this period the character is not generic, as in Ixalus, Tab. II. The period of losing the tail, like that of breeding, is represented as occurring at nearly the same time in the history of every genus, as it is generally seasonal. Yet this is not always so, and like the other characters has most likely had its period of shifting. Compare difference of time of development, for instance, of the frontal and prefrontal bones in Tabs. I. and IV. The comparison of the adult stages of the less developed genera, at the tops of the columns, with the larval conditions of those more fully developed, may be traced in the absence of characters which appear in the latter. I have convinced myself of the accuracy of the above relations by the examination of many skeletons and wet preparations of adults and larvæ.

The tables* are representations of nature, and not ideal sketches. It is to be noted as remarkable, that the advance throughout so many diverse groups is in the *same direction*, viz., to complete or excessive ossification of the cranium; and this identity of progress might be readily shown by adding other characters, were it not that the tables would become too complex for convenience.

Has any such transition from genus to genus ever been seen to occur?

It must of course take place during the life of the individuals of a species, and probably at different times during the lives of different individuals, dependent on their relative vigor. In our view, ordinary metamorphosis is such a change, and we have stated its bearing in this form, that "every character distinguishing suborders, families and genera is to be found among the individuals of some species, living or extinct, to mark new varieties or stages of growth."

α. The developmental relation of generic to specific characters.

For the relation of the law of retardation and acceleration to specific characters we will look to development again. While the young of Trachycephalus are successively different genera, they preserve most of their specific characters so as not to be mistaken. Agassiz says of the development of the North American turtles,† "I do not know a turtle which does not exhibit marked specific peculiarities long before its generic characters are fully developed." The same thing can be said of the characters of our salamanders, whose specific marks appear before their generic, or even family characters. I suspect that this will be found to be a universal law.

It also follows, if a developmental process, as proposed, has existed, that at times *the change of generic type has taken place more rapidly than that of*

* Notes on the tables.—I. I characterized a genus Zaphrissa (Journ. A. N. S., 1866) from the Braunkohle (miocene) of Prussia, as different from Latonia, on the ground of the presence of a fontanelle in the exostosed frontoparietal bones. This combination of characters is very improbable, and appeared so at the time; but the appearance of the specimen is quite clear in this respect. I think, however, it must be the result of injury, and that the roof has been partially carried away.

Tab. II. Polypedates is here restricted to P. maculatus and P. quadrilineatus. The other species are referred to Rhacophorus, which has not hitherto rested on any proper basis; the asserted character—the palmation of the hands—being one quite graduated from species to species among Hylæ. *Chiromantis*, Peters, is referred to the same, as its character is not strongly marked and is visible in other species. For similar reasons *Leptomantis* is referred to Ixalus.

Tab. IV. In each of series II and III two series are mingled for the sake of comparing the structures of the prefontal bones. Thus Heteroglossa, Staurois, Hylorana and Trypheropsis are one series, and Hyperolius and Hylambates members of another.

† Contrib. N. Hist. United States, I., p. 391. Note.

specific, and that one and the same species (if origin be the definition,) has, in the natural succession, existed in more than one genus.*

Apart from any question of origin, so soon as a species should assume a new generic character it ceases, of course, to be specifically the same as other individuals which have not assumed it. If supposed distinctness of origin be, however, a test of specific difference, we shall then have to contend with the paradox of the same species belonging to two different genera at one and the same time.

It follows, therefore, in our interpretation of nature, that groups defined by coloration alone are not to be regarded as genera, as is done by some ornithologists and entomologists. They are simply groups of species in which distinctive generic characters had not appeared up to the period of reproduction. Inasmuch as in development certain specific characters appear first, among them part or all of the coloration pattern, it is obvious that the latter do not belong to the generic category. The employment of such characters then, in this sense, is only to commence reversing the terms generic and specific, and to inaugurate the process of regarding each species as type of a separate genus.

β. Of probable cases of transition.

Thus the transition between the toothed and edentulous conditions in Cetacea takes place in the ordinary growth of the individuals of the genus Globiocephalus, and the transition between the ossified and non-ossified types of Chelonia occurs during the life of the individuals of the genus Dermatemys.

But in attempting to demonstrate this proposition we must bring forward facts of another kind. The anti-developmentalists are accustomed to put such changes aside, as part of the necessary history of established types; hence we will not appeal to such.

1. The frog Ranula affinis, of South America, was described by Peters as probably a climatal variety of European Rana temporaria. In this he is supported by the fact that the specific characters do not differ more than would characterize it as a local variety, were it an inhabitant of Europe. But I have found that it differs generically in the non-ossification of the ethmoid bone, as has been confirmed by Steindachner, and represents an embryonic condition of the same bone in Rana. It is in fact an undeveloped Rana. That this is a true genus is confirmed by many specimens, by an additional species (R. palmipes), and by the fact that the allied genus Trypheropsis, embracing three species in the same region, differs in the same way from the otherwise identical genus of the Old World, Hylorana.

2. The South African Saurians Chamæsaura anguina, and Mancus macrolepis, are very closely allied in specific characters in all respects, though distinct. They have one important ground of generic distinction; the latter has one pair of limbs less than the former. They are rudimental in Chamæsaura, and the disappearance in Mancus is but another step in the same direction. The difference in specific characters is of much less degree.

3. In the genus Celestus there are numerous species, which range from a slender, snake-like form with weak limbs, to stouter, strong-limbed forms with a more saurian build. Among these the Haytian C. phoxinus is well disguished by form and coloration. An allied genus from the same region is Panolopus, which in specific characters approaches the C. phoxinus very closely, much more so than any Celestus (one species possibly excepted). But in generic characters it is distinguished by the loss of all its toes and the non-separation of nine plates on the end of the muzzle. The genus Diploglossus, on the other hand, occupying a superior place on account of the division of the frontonasal into three, is, in specific characters (of D. monotropis) much

* See Proceedings Academy, 1867, p. 86, where I observe that generic characters are probably less inherent than specific.

closer to the stout Celesti than the species of the latter genus are among themselves.

4. The Gronias nigrilabris is a Silurid, which in specific characters more nearly resembles the Amiurus lynx, than the latter does the A. albidus and many other species of the genus. The A. lynx is found in the same streams. The important generic character, the absence of eyes, is, however, its constant feature (in three specimens known to naturalists, others to fishermen).

5. The Cinclidium granulatum, a large tree toad of Brazil, resembles in all its characters the Centrotelma geographicum. The specific differences between them amount to almost nothing, but both sexes of the former grow larger and are furnished with a generic peculiarity in the addition of some phalanges to the thumb.

6. The Auk Sagmatorrhina suckleyi Cass. is stated* to resemble in plumage and all its characters the Ceratorhyncha monocerata, as to be not distinguishable, even as a variety from it, except by the striking generic characters. In the latter a concave bone-like process rises from above the nostril, and an accessory piece is found in the symphysis mandibuli, both wanting in the genus Sagmatorrhina.

7. The Oporornis agilis Baird, a North American bird of the Tanager family, resembles very closely in form, color and habits, the adjacent species of the adjacent genus Geothlypis. While its specific characters are thus very close to Geothlypis tephrocotis, it differs in the generic feature of a longer wing. By this it is associated, and properly so, with another species, O. formosus, which has the general color and habits of species of Myiodioctes (M. canadensis), the next related genus.

8. The following fact I give on the authority of Prof. Leidy, who will publish it in his forthcoming work on the extinct mammalia of Nebraska, etc.

Three species of Oreodon occur in the miocene strata; they are a larger, a medium and a small sized species. In the Pliocene beds above them they are represented by three species of Merychyus, which are in all respects known, identical specifically with the three preceding. Each one may thus be said to be more nearly allied to the species of the other genus than to its fellow of the same genus, in specific characters. But each, on the other hand, differs from each in generic characters. The teeth of Merychyus are more prismatic, have longer crowns and shorter roots, approaching the sheep, as Oreodon does the deer.†

9. The North American Centrarchoid, Hemioplites simulans, in specific characters is most closely allied to the Enneacanthus guttatus Morris.* It has however one or two distinctive specific features, but it differs as to genus in having one less dorsal spine and one more anal spine, characters in the direct line of succession of genera to Centrarchus and Hyperistius. Now the lack of one of its dorsal spines is not an uncommon variation in the Enneacanthus, but the anal is never known to change. There is, however, apparently no reason, as far as physical causes are concerned, why it should not tend to vary as much as the dorsal. The lack of this tendency constitutes Hemioplites, a genus distinct from Enneacanthus, *at the present time.*

* By Coues Monograph of Alcidæ. Proc. Acad. Phila., 1868, p. 34.

† This phenomenon suggests an explanation on the score of adaptation, which the other cases do not. The existence during the later period of a tougher material of diet, would increase the rapidity of wearing of the crown of the tooth, and require a longer crown and greater rapidity of protrusion. This necessitates a diminution of the basal shoulder and shortening of the roots, producing the prismatic form aforesaid. The deer browse on forest foliage, which is more tender, while the Cavicornia graze the grasses, which contain, as is known, a greater amount of silex; hence the more rapid attrition of the tooth.

This may have been the case with the two extinct genera; the different periods during which they lived may have seen a change from forest to prairie. (It is not intended to insinuate that the species of the two genera are necessarily of the same or any given number.)

Those naturalists (who are not a few) who will be disposed on this account to deny generic rank to Hemioplites, will have, on the same grounds, to unite each succeeding step till they embrace the "series," and no doubt at the same time belie a considerable amount of their own work already done.

10. The Coreopsis discoidea T. and G, var. *anomala* Gray, is much more nearly allied to Bidens frondosa than to other species of its own genus, and the latter is nearer to it than to other species of Bidens. It differs chiefly, if not altogether, in the generic character: the barbs of the achenia are directed upwards; those of the Bidens downwards.

From these and many other such instances it may be derived: *That the nearest species of adjacent genera are more nearly allied in specific characters than the most diverse species of the same genus.*

11. While Taxodium distichum and Glyptostrobus europæus, conifers of North America and of Eastern Asia, respectively, are readily distinguished by generic peculiarities of their cones; in specific characters they appear to be identical.*

Confirmatory of this proposition is the statement of Parker:† "In tracing out the almost infinite varieties of the modifications of any one specific type of shelled Rhizopod, my friend, Prof. Rupert Jones and I found that *like varieties of distinct species are much nearer in shape and appearance than unlike varieties of the same essential species.*" (It is not unlikely that species should here be read genus and variety species, though the latter may not fulfil the requirements in regard to distinctiveness observed among higher animals. In types like the Rhizopod, forms of this grade may not be really differentiated. Their enormous geographical range would suggest this, if nothing else.)

Objection.—A class of objectors to the preceding explanation of the relations in question, will ascribe them to hybridization. They have already done so to considerable extent among the Teleosts, (see the writings of Von Siebold, Steindachner and Günther). That hybrids exist in nature will be denied by none, but that they are usual or abundant is not a probable condition of a creation regulated by such order as ours is. The tendency to modify in given lines of generic series, if admitted, will account for many of the cases regarded as hybrids by the above authors, for it is to be remarked in many cases how the generic characters are strikingly affected, and are chiefly used in guessing at the parentage. This is among Cyprinidæ so much the case that their is scarce an example of a hybrid between two species of the same genus brought forward, but often between species of different genera.

If any two forms should hybridize freely, the circumstance should prevent their recognition as distinct species.

γ *Ascertained cases of transition.*

This naturally suggests that in accordance with the theory of acceleration and retardation, a transition can take place in the life history of species. Have we any means of proving this suspicion?

1. The genus Ameiva (Saurians of South America) has been composed of species of moderate size furnished with acutely tricuspid teeth. Teius, on the other hand, embraces very large species with the molars obtusely rounded and of the grinding type. These genera are generally held to be well founded at present. I find, however, that in Ameiva pleii, which is the largest species of the genus, that in adults the greater part of the maxillary and mandibular teeth lose their cusps, become rounded, then obtuse, and finally like those of Teius. While young, they are true Ameivæ. Strangely enough the A. pleii, from Porto Rico, acquires but three such obtuse teeth when of the size of the other (St. Croix) forms. In youth the teeth of all are as in other Ameivæ. Here is a case of transition from one genus to another in the same species.

* See Meehan, Proc. Amer. Ass. Adv. Sci. 1868. Newberry, Ann. Lyc., N. Y., 1868.
† Transac. Zool. Soc., London, 1864, 151.

2. In the important characters of the possession of branchiæ, of maxillary bones, and of ossified vertebræ, the tailed Batrachia presents a series of a rising scale, measured by their successively earlier assumption. Thus Salamandra a t r a* produces living young, which have already lost the branchiæ; S. m a c u l o s a living young with branchiæ; Plethodon † produces young from eggs which bear branchiæ but a short time, and do not use them functionally; Desmognathus n i g r a uses them during a very short aquatic life; D. f u s c a and other Salamanders maintains them longer, while Spelerpes preserves them till full length is nearly reached. Finally species of Amblystoma reproduce while carrying branchiæ, thus transmitting this feature to their young as an adult character And it is a very significant fact that Spelerpes, which bears branchiæ longest, next to Amblystoma, is associated in the same zoological region with a genus (Necturus) which differs from its four-toed form (Batrachoseps‡), in nothing more than the possession of the osseous and branchial characters of its larva, in a permanent and reproducing condition. That this is a genus, to be one day converted into Batrachoseps by an acceleration of its metamorphosis, or that has been derived from it by the reverse process, I am much inclined to believe. In support of this I quote the following examination into the time of change of the species of Amblystoma from my essay on that genus.§

"The great difference between the different species, and between individuals of the same species in this respect, may be illustrated by the following comparison between the size of the animals at the time of losing the branchiæ so far as known, and that to which they ultimately attain.

Species.	Size at loss of branchiæ.		Average full size.	
	In.	Lines.	In.	Lines.
A. jeffersonianum,	1	5·75	6	
A. punctatum,	1	10	6·1	6
A. conspersum,	1	10·5	2	7·5
A. opacum,	2	2	3	9·5
A. texense,	2	1	?	
A. microstomum,	2	3·5	4	
A. talpoideum,	3 (perhaps too large)		3	9·5
A. paroticum,	3	7·5 (not smallest.)	7·2	2·5
A. tigrinum,	3 6	7 to 7	8 to 10	
A. mavortium,	3 8	9·5 to 0	8	9
A. mexicanum,	? branchiæ persistent.		8	

The last species, though not uncommon in collections, is not known to pass through its metamorphoses in its native country, but reproduces as a larva, and is therefore type of the genus *Siredon* of Wagler, Cuvier, Owen and others. The larva of A. m a v o r t i u m in like manner reproduces, but their offspring have in the Jardin des Plantes and at Yale College undergone an early metamorphosis.||

Here is a case where all the species but two change their generic characters; one changes them or not, according to circumstances, and one does not change them at all. What are the probabilities respecting the change in the first set of species?

* See Schreibers Isis, 1833, 527: Kœlliker, Zeitschr. f. Wissensch. Zoologie, ix, 464.

† Baird Iconographic Encyclopædia, Wyman, Cope.

‡ See Cope, Journ. Ac. Nat. Sci., Phila., 1866.

§ Proceed. Academy, 1867.

|| Through the kindness of Prof. Dumeril, I have received both larvæ and adult of the species here noted, and observed by him. The larva is as he states, *Siredon lichenoides* of Baird, while the adult is his Amblystoma m a v o r t i u m, not A. t i g r i n u m (= *luridum*) as also supposed by Dumeril.

As we know from the experiments of Hogg, Duméril and others that metamorphosis is greatly hastened or delayed by the conditions of temperature and light, what would not be the effect on such a protean species of a change of topographical situation, such as the elevation or depression of the land? And I have no hesitation in saying that if the peculiarities of series of individuals of A. tigrinum and A. mavortium, in the respects above enumerated, were permanent, they would characterize those series as species, as completely as any that zoologists are accustomed to recognize. For the evidences on this head, see the discussions of those species in my monograph.

The experiments of Hogg above alluded to, are as follows, as given by him in the Annals and Magazine of Natural History.

He placed a number of impregnated ova of frogs in vessels arranged at regular distances from the light, in a cave. The lessening degrees of light were of course accompanied by a corresponding but much less rapid decline in temperature. The resulting effects on the metamorphosis may be tabulated as follows:

Mo.	day.	60°	56°	53°	51°
3	11	Egg.	Egg.	Egg.	Egg.
	20	Larva free,	*	*	*
	25	*	Larva free,	*	*
	31	*	*	Larva free,	Larva free,
4	10	Larva very large,	*	*	*
	22	Metam. complete,	Larva large,	Larva large,	Larva small,
8	11		Metam. complete,	*	*
	28			Metam. complt.	*
10	31				Metam. comp.

3. The reproduction of some species of insects before they complete their metamorphosis is a well-known fact, and it is particularly to the point that, in many of them, some individuals do attain to their full development, while the many do not. Westwood says,* "two British species of this family (the Reduviidæ), Prostemma guttula and Coranus subapterus, are interesting on account of their being generally found in an undeveloped state, the latter being either entirely apterous or with the fore-wings rudimental, although occasionally met with having the fore-wings completely developed. "I think," says Spinola, "that the presence of wings and their development depends on the climate," and in speaking of Oncocephalus griseus, he says "the influence of the northern climate appears to have arrested the development of the organs of flight." It will be seen that I have referred elsewhere that I have noticed that it is especially in hot seasons that certain species acquire, while the circumstance noticed respecting the ordinary occurrence of winged specimens of Microcœlia in the West indies is confirmatory of the same opinion."

4. It is now known that certain Orthoptera do not get through their metamorphosis in time for the period of reproduction, and hence never or in rare instances only develope more than a short distance beyond the pupa state.

5. My friend, P. R. Uhler, tells me of an example among Hemiptera of the genus Velia. The species V. rivulorum Fab., and V. currens* of Europe, are only distinguished by the developmental feature of the presence of wings in one, and their absence in the other. Another species of the tropical region of the West Indies, Halobates americanus Uhler, is furnished with wings, while its individuals which occur abundantly in North America have been generally supposed to lack them. Individuals, however, no doubt occur whose developments is so far accelerated as to permit them to acquire wings before the period of reproduction, since one such has been found by Uhler.

* Uhler informs me that Amyot's asserted color characters are not reliable.

These wing characters are in many cases generic, it appears to the writer; and the fact that they differ without corresponding specific differences, is important evidence as to the origin of genera.

6. The females of the Lepidopterous genus Thyridopteryx never develope beyond the pupa state, according to the same authority, before reproduction; they are reproducing pupæ, so far as the external characters concerned in metamorphosis go. In other words, the latter have been retarded, while the reproductive system and others have progressed. Now generic characters are seen in the first, not in the last. The influence of the males is sufficient to prevent more than a part of the offspring from being retarded in the same manner.

I have selected a few of this class of facts which have come before my mind during the present writing, as drawn mainly from my own experience. How many more of the same purport could be found by search through the great literature of science or in the field of nature, may be readily imagined. I have no doubt that the field of Entomology especially will furnish a great number of evidences of the theory of acceleration and retardation, especially among the insects with active pupæ.

Finally, having already stated the law according to which these processes naturally take place, I quote the following significant language of Hyatt in the above quoted essay on the Cephalopoda, as approaching nearer to the "law of acceleration and retardation," than any thing I have found written. He says:

"In other words there is an increasing concentration of the adult characteristics of lower species, in the young of higher species, and a consequent displacement of other embryonic features, which had themselves, also, previously belonged to the adult periods of still lower forms."

The preceding propositions have been formulated as follows; a few additions being now made:

I. That genera form series indicated by successional differences of structural character, so that one extreme of such series is very different from the other, by the regular addition or subtraction of characters, step by step.†

II. That one extreme of such series is a more generalized type, nearly approaching in characters the corresponding extreme of other series.

III. That the other extreme of such series is excessively modified and specialized, and so diverging from all other forms as to admit of no type of form beyond it.‡

IV. That the peculiarities presented by such extremes are either only in part or not at all of the nature of adaptations to the external life of the type.§

V. That rudimental organs are undeveloped or degraded conditions of the respective characters developed or obliterated in the extreme of the series.

VI. That the differences between genera of the same *natural* series are only in the single modifications of those characters which characterize the extreme of that series.

VII. That the relations of the genera of a primary series, are those of the different steps in the development of the individuals of the extreme genus *ab ovo* (*Von Baer*, *Agassiz*) (with sometimes the addition of special adaptive features? ?)

VIII. That the presence, rudimental condition, or absence of a given generic character can be accounted for on the hypothesis of a greater rapidity of de-

* On Insects, II, 473.

† St. Hilaire, Owen, Agassiz, Duméril.

‡ Dana on Cephalization; Leconte.

§ Owen on Cetacea, Trans. Zool. Soc., Lon., 1866, 44. Leconte on Carabidæ, Trans. Amer. Philos. Soc., 1853, 364.

velopment in the individuals of the species of the extreme type, such stimulus being more and more vigorous in the individuals of the types as we advance towards the same, or by a reversed impulse of development, where the extreme is characterized by absence or "mutilation" of characters.

IX. And that as the character of the genus at the period of reproduction of its species, is that which is perpetuated;

X. So the character of the genus has been first inferior, then protean, and then advanced, as the metamorphosis has been by a retrograde movement in time, posterior to, at, or anterior to the period of reproduction.

XI. That it therefore results that there is one primary structural type involved in such a series of species, which is made to present at any given period in its Geologic history that appearance of succession of genera ordained by Creative Power.

δ. On the origin of inexact parallelism.

The hypothesis can only be demonstrated in case of *exact parallelism.* If proven in these, it readily accounts for the cases of *inexact parallelism*, which are of course in any single period vastly in the majority. First take the case of *simple inexact parallelism.* A series of individuals of the genus Didocus undergo the metamorphosis of the cranial structure earlier and earlier in life, commencing by completing the ossification of the perichondrium of the fronto-parietal region in full age, until at last it becomes completed as early as the period of reproduction. Heretofore the adult offspring have appeared during a long period, invariably characterized by the larval cranium, but like now producing like, this development springs into new power, and the offspring ossify the cranial bones far earlier than their immediate predecessors; in a word, the genus Pelobates has been created! At this state of progress Didocus is an undeveloped Pelobates.

Let us, however, suppose the "acceleration" of development of the cranial bones still to progress. The character appears now soon after the ordinary metamorphosis has been passed, and now a little before. The identity of Didocus with the undeveloped Pelobates is thereupon lost!

So may have been the relations between Pelobates and Cultripes. Pelobates was probably once identical with the undeveloped Cultripes, but the same acceleration has concentrated the characters more rapidly than the other larval stages, leaving Pelobates behind.

This I conceive to be the explanation of this relation: when the parallelism is inexact by two steps, as in Spea to Didocus, by the obliterated ear and ossified xiphisternum. The continued concentration of characters has been carried to earlier stages till the identity exists in the adult state of neither one but at a period of larval life of both, shortly preceding the adult period of the lower. The relations between the Amblystomidæ and Plethodontidæ, which I have elsewhere * pointed out, have probably had their origin in this way.

If we attempt to prove the identity of the modern mammalian fœtal circulation with that of the modern adult fish, we may find nearly an exact parallel in this respect, as it is the basis of class distinction; but in other respects the identity will not exist, rendering the parallel inexact or remote. The structure of the origins of the aorta is at one time identical with that of the shark, with one exception—in the former but four aorta-bows appear together; in the latter five. In the former the first disappears as the fifth comes into being. This is simply a continuation of *acceleration.* The first generalized representative of the Mammalia lost the first aorta-bow towards the latter part of its growth, and became the next genus in advance of the selachian. The fact that these bows do not appear exactly simultaneously, but rather successively, renders it necessary that in a regularly shortening period of possession of

* Jour. Ac. Nat. Sci., Phil., 1866, 100.

transitory characters, one such, as the existence of the first aorta root, should vanish before the appearance of a permanent, the fifth, in the more specialized types, where acceleration reaches its maximum. This is indicated by the fact that in the Batrachia, where the acceleration has not attained so high a degree, the first and fifth aorta-bows coexist for some time, though the first and second disappear before maturity.

So also with the splitting of the bulbus arteriosus. As in the Batrachia, the pulmonary *ductus communis* only is to be separated, the remaining bulbus is divided by a long valve or incomplete septum, tracing the division of the aorta roots. In the serpent (Rathke), this division is so accelerated as to appear at nearly the same time as the septum of the pulmonary duct. In the mammal, on the other hand, while the division of the aorta root takes place as soon as in the last, the pulmonary septum is accelerated so as to appear long before the first named. Hence in the septa in the serpent, the singular anomaly seems to present, of the mammal passing through the Batrachian stage while the serpent, a nearer relative, does not.* If, however, we take the less typical serpent, we will find the aortic septum to appear a little later, thus giving the Batrachian type, and if we reverse the order of time, so that the succession becomes one of retardations, we will find the same known ratio will bring us to an identity under all circumstances.

This then is the explanation of the divergence and want of "exact parallelism" which is observed in comparing the developmental histories of all types *not most closely allied. It has not*, according to our theory, *always been* a divergence, but was at a prior epoch in each case a relation of "exact parallelism," the lower type a repressed higher; the former identical with one of the stages of the latter. But the process which has produced this relation, continued, has of necessity destroyed it, so that the exact parallelism has always been a temporary relation, and one shifting over the face of the system.

III. *Of higher groups.*

First; comparison of the cotemporary.

Having now admitted a developmental succession of genera, and second, that this has progressed more rapidly at certain times in the earth's history than any modification of specific forms, the hypothesis already broached naturally comes up. *Has such transformation of types, generic or higher, taken place in any degree simultaneously, throughout a great number of species?* An affirmative answer to such a proposition is absolutely necessary to its acceptance as expressing the phenomena exhibited by geological succession of types. Let us try to answer the question put in a closer form. Have the same species been transferred from one geologic epoch to another by a change of generic form; and has not the genus been transferred from one epoch to another under change of ordinal type? and as a consequence the same species?

As a reply, I propose to render the affirmative of the first of these questions highly probable.

Palæontology only will be able to answer this question conclusively, though as we have abundant evidence that the relations of species to genera and other higher groups were the same then as now, we may look to the present status as furnishing important evidence on the subject. We are turned at once to the probable history of development in the separate zoological areas of the earth's surface. The question may be asked, Are the present zoological regions on an equal plane as to the geologic relations of their faunæ, or are they related as the different subdivisions of a geologic period in time?

I have on a former occasion asserted that the latter of these propositions was true.†

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*This is the way indeed in which it is stated by Rathke, Entwickelungsgeschichte der Natter p. 164.

† On Arciferous Anura, Journ. Ac. Nat. Sci., 1866, 108.

α. Of homologous groups.

Naturally following the admission of a developmental succession of organic beings, is the question of its relation to the different surfaces of land and water on the earth. The following considerations bear on this subject.

Among the higher groups of animals can be detected series "homologous" on the same principle as the alcohols (? compound radicals) and their derivatives; and the component types of each can be, and have been in many instances, shown to be "heterologous," as are the ethers, mercaptans, aldehydes, acids, etc. Among Mammalia two partly homologous series have been pointed out, Implacentialia and Placentialia;* possibly such are the types Altrices and Pracæoces among Aves; of a lesser grade in this class are the parallel series of Pullastræ and Gallinæ, of Clamatores and Oscines. Among Tortoises I have alluded to the Pleurodira as compared with the remainder of the order, already parallelized by Wagler; and of lesser grades, the series among Lacertilia of Acrodonta and Iguania, parallelized by Duméril and Bibron, and of Teidæ and Lacertidæ, compared by Wiegmann. I have discovered a full parallelism between the Raniform and Arciferous Anura. It is carried out between the Characini and a group of remaining Physostomous Fishes, perhaps not yet well defined; it is exhibited between the orders Diptera and Hymenoptera among insects. None of these comparisons can be allowed, of course, without the most searching anatomical and embryological analysis.

This *heterology* is what Swainson and others called "analogy" as distinguished from affinity. It *generally* relates genera of different zoological regions. Mimetic analogy, on the contrary, relates genera of the same region; it is a superficial imitation which has occurred to critical biologists, and is of much interest, though as yet but little investigated. It has as yet been observed in external characters only, but occurs in internal also; it has been accounted for in the first case by the supposed immunity from enemies arising from resemblance to well defended types. No such explanation will, however, answer in the latter case. I believe such coincidences express merely the developmental type common to many heterologous series of a given Zoological "Region;" this will be alluded to a few pages later.

We naturally inquire, is there anything in the food, the vegetation, or the temperature to account for this apparent diversity in the different regions? Are there not carnivora, herbivora, seed-eaters, insectivores, and tree climbers, where game and grass, seeds and insects and forests grow the world over? We answer undoubtedly there are, and these adaptations to food and climate are indeed as nothing in the general plan of creation, for every type of every age has performed these functions successively.

β. Of Heterology.

This relation will be exhibited by a few examples from groups known to the writer, commencing with the Batrachia Anura.

	Raniformes.	Arciferi.
External metatarsal free.		
Aquatic.	Rana.	Pseudis.
Metatars. shovel.	Hoplobatrachus.	Mixophyes.
External metatarsal attached.		
	Feet webbed.	
Metatars. shovel.	Pyxicephalus.	Tomopterna.
Arboreal; vom. teeth.	Leptopelis.	Hyla.
" no " "	Hyperolius.	Hylella.
Subarboreal.	Hylambates.	Nototrema.
	Feet not webbed.	
Terrestrial.	Cassina.	Cystignathus.
" spurred,	Hemimantis.	Gomphobates.

Comparing the genera in a general physiological sense we may parallelize further.

Aquatic, with digital dilatations.	Heteroglossa.	Acris.
Arboreal; cranium hyperostosed.	Polypedates.	Trachycephalus.
" cranium free.	Rhacophorus.	Hyla. Agalychnis.

The same kind of parallels exist between the primary groups of the Testudinata, as follows:

	CRYPTODIRA.	PLEURODIRA.
Five complete pairs of bones across the plastron.	Pleurosternidæ.	Sternothæridæ.
Four pairs of bones across plastron; not more than two phalanges on all toes.	Testudinidæ.	Pelomedusidæ.
Three phalanges on most digits;		
Zygomatic arch; no parieto-mastoid.	Emydidæ.	Podocnemididæ.
Temporal fossa overroofed by parietal.	Macrochelys.	Podocnemis.
No zygoma; a parieto-mastoid arch. *	* *	Hydraspididæ.

If we compare the peculiarities of generic structure merely with reference to their adaptation to the animals habits, we will see the following:

	CRYPTODIRA.	PLEURODIRA.
Feet reduced for terrestrial progress.	Testudinidæ.	Pelomedusidæ.
Feet normal.		
Anterior lobe of sternum moveable.	Cistudo. Cinosternum.	Sternothærus.
Anterior lobe fixed.		
Neck very elongate.	Trionychidæ.	Chelodina.
Neck shorter; aquatic.		
Temporal fossa open.	Emydidæ in gen.	Hydraspididæ.
Temporal fossa over-roofed.	Cheloniidæ.	Podocnemis.

The parallels between the genera of the American Iguanidæ and the old world Agamidæ are similarly quite close.

	IGUANIDÆ	AGAMIDÆ.
Abdominal ribs.	Polychrus.	* *
No abdominal ribs.		
Ribs greatly prolonged into a lateral wing.	* *	Draco.
Ribs not prolonged.		
Arboreal types, generally compressed.		
A dorsal and caudal fin supported by bony rays.	Basiliscus (no fem. pores)	Lophura (pores.)
No vertebral fin.		

	No femoral pores.	
Form slender, scales in equal series,	Calotes. Bronchocela. }	Læmanctus.
Form elongate; eyebrows elevated, tail compressed.	Gonyocephalus.	Ophryoëssa.
Form stouter, scales less regular.	Hypsibates.	Tiaris.
	Femoral pores.	
Low crested; small hyoid disk.	Brachylophus.	Diporophora.
High crested; large hyoid disc.	Iguana.	Physignathus.
Tail with spinous whorls.	Cyclura.	* *
Terrestrial types of flattened form.		
	Femoral pores.	
Tail with whorls of spiny scales.	Hoplocercus.	Uromastix.
Tail long, simple; scales small.	Crotaphytus.	Liolepis.
Tail simple, scales large.	Sceloporus.	* *
	No femoral pores; preanal pores.	
Tail with whorls of spines.	* *	Stellio.
Tail simple, not elongate, ear open.	Proctotretus.	Agama.
	Neither femoral nor anal pores. Much flattened, tail short, scales irregular.	
Ear exposed.	Phrynosoma.	Moloch.
Ear concealed.	(Doliosaurus, s. g.)	{ Phrynocephalus. Megalochilus.

A similar parallel may be drawn between the American Teidæ, and the old world Lacertidæ, and in fact between all the families of the Lacertilia Leptoglossa. I have added to these for comparison two families of the Typhlophthalmi. Each family embraces one or more series, and these exhibit a remarkable similarity in the relative development of the limbs and digits; among the higher groups the parallelisms lie in the arrangement,—as greater or less separation, of the head shields. The Scincidæ are cosmopolite; the Gymnophthalmidæ, which have the eyelids of their fœtus, are Australian; the Sepsidæ, either larval or senile in head shields, are mostly Æthiopian.

The first comparison of these groups was made by Wiegmann (Herpetologia Mexicana.) who employed, however, only the Scincidæ and Lacertidæ, and could not include the many types made known since his day.

From the class Aves I have selected only the homologous series of the Clanatorial and Oscine Passeres. Naturalists more fully acquainted with the genera could probably increase the examples of heterology largely. Each group furnishes us with carnivorous, insectivorous and frugivorous forms; each with walkers, climbers, and sedentary genera; each with butcher-birds, thrushes, warblers (not in song!), wrens and fly-catchers. Each and all of these types are *teleologically* necessary to any country complete in the wealth of nature, and to each geological period.

Two pair limbs. I. Toes 5—5.	*Lacertidæ.*	*Teidæ.* (*no supranasals.*)	*Anguidæ.*	*Gymnopthalmidæ.*	*Scincidæ.*	*Sepsidæ.*	*Pygopodidæ.*	*Acontiadidæ* & *Anelytropidæ.*
A. Scales granular.	Lacerta.	Amēiva. Cnemidophorus.						
	Eremias.							
B. Scales imbricate.	Notopholis.							
Supranasals. Prefrontals, 2. (divided.)	Gerrhosaurus.	Centropyx.	Diploglossus.	Morethia.	Euprepis. Eumeces.			
Prefrontals, 0.	Pleurostrichus.		Celestus.			Amphiglossus. Sphenops. Gongylus.		
No supranasals.	Platysaurus.... Cicigna.	Cercosaura. Iphisa. Ecpleopus. Lepidosoma.		Cryptoblepharus. Ablepharus.	Cyclodus. Hinulia. Mocoa.			
II. Toes 4—5.		Tretioscincus. (Acrantus.)		Menetia. Gymnophthalmus.	Campsodactylus. Ristella. Heteropus.			
III. Divided 3—3 to 2—3 times.	Saurophis.	Brachypus.	Sauresia.	Miculia. Blepharactisis.	Tetradactylus. Chiamela.	Sepsina. Anisoterma, (2—4)		
IV. Divided 1—2 or 2—1 or 2—2.		Chalcis.		Lerista.	Anomalopus. Siaphus. Hemiergus. Chelomeles.	Seps. Heteromeles. Sphenocephalus. Sepomorphrus.		Nessia.
V. One limb divided.		Ophiognomon.			Brachymeles. Rhodona.			
VI. Neither divided.	Cætia. Chamæsaura.		Panolopus.					Evesia.
One pair limbs.	Mancus.		Pseudopus.			Scelotes.	Pygopus. Delma. Pletholax.	Dibamus.
No limbs.			Opheodes. Opheosaurus. Anguis. Opheomorus.		Soridia.		Aprasia.	Herpetosaura. Acontias. Typhlosaurus. Feylinia. Anelytrops.

Clamatores.		Oscines.

I. Tree-climbers, with long hind toe and tail feathers stiffened and acute.

Dendrocolaptidæ.	*Certhiidæ.*

II. Terrestrial in part, with the tertials as long as the primary quills.

Geobatidæ.	*Motacillidæ.*

III. Tree-perchers with hooked bill, graduating from powerful to medium and slender.

Formicariidæ.		*Turdidæ.*
Thamnophilus.	Bill strongest, hooked.	*Lanius.*
Formicarius.	" moderate.	*Turdus.*
Formicivora.	" weak.	*Sylvia.*
Rhamphocœmus.	" slender (wrens).	*Troglodytes.*

IV. Fly-catchers with flat bill and weak legs; wait for their prey and take it on the wing.

Tyrannidæ.	*Muscicapa* et aff.

V. Flat-billed berry and fruit eaters.

Cotingidæ.	*Bombycillidæ.*

From the Mammalia the well-known series of the Marsupialia and Placentialia may be chosen.

Placentialia.		Marsupialia.

I. Toes unguiculate, in normal number; sectorial teeth; *i. e.*, one or more molars with one or no internal tubercles; canines strong:

Carnivora.		*Sarcophaga.**
	I. Digitigrade.	
	Toes 5—4.	
	b. Numerous sectorial tuberculars.	
Canidæ.	Tubercular molars $\frac{2}{2}$.	* *
* *	Tubercular molars $\frac{4}{4}$ (upper incisors more numerous in some).	Thylacinidæ.
	II. Plantigrade; molars tubercular.	
* *	*a.* Posterior molars $\frac{4}{4}$.	Dasyuridæ.
Ursidæ.	*aa.* Posterior molars $\frac{2}{2}$.	* *

II. Toes unguiculate; molars with more than one row of pointed tubercles; canines weak or none; incisors large.

Insectivora.		*Entomophaga.*
	a. True molars $\frac{4}{4}$, toes 4—5.	
Gymnura.	Tail naked.	Didelphys.
Cladobates.	Tail hairy.	Myoictis.

IV. Molars with transverse crests, no canines; tusk-like incisors; pairs of limbs of similar proportions.

* Flower and Krefft show that the supposed carniverous Thylacoleo Ow. is allied to Hypsiprymus, and probably similar in habits.

Proboscidia.		*Diprotodontidæ.*
	Two inferior incisors; molars with two cross-crests; size huge.	
	a. Two rudimental lateral incisors above.	
*	*	Diprotodon.
	aa. ? One pair of incisors only above; a trunk.	
Dinotherium.		

V. No canines; two pairs of cutting incisors.

	a. Three true molars.	
Rodentia.		* *
	aa. Four true molars.	
* *		*Rhizophaga.*

The parallels are in this case very imperfect in details, and but few worthy of the name can be made. They are, however, illustrative of a remote heterology, sufficiently remarkable to have claimed the notice of naturalists for many years.* I also have little doubt but that future palæontological discoveries will increase the number of parallels, but bring to light truly heterologous generic terms of the Marsupial series. Predictions of this kind have been on many occasions fulfilled (*e. g.*, some of D'Orbigny's among the Cephalopoda), and I look with confidence to the ultimate demonstration of that heterology here, which has been already seen in the Batrachia and Reptilia.

The homologous groups of the Catarrhine and Platyrrhine Quadrumana are measured as follows:

	Catarrhini.	*Platyrrhini.*
Tailless.	Andropithecus.	*
	Simia.	*
	Hylobates.	*
Tail short.	Cynocephalus.	*
	Macacus.	Brachyurus.
Long tail.		
Thumb developed.		
	Cercopithecus.	Lagothrix.
		Mycetes.
Thumb rudimental.		
	Semnopithecus.	Brachyteles.
Thumb none.		
	Colobus.	Ateles.

I append two homologous series, represented by the Nautilea and the Ammonites of the Tetrabranchiate Cephalopoda, which are distinguished, the first by the simple septa and the siphon central or marginal ventral; and the second by the complex and folded septa and siphon central or marginal dorsal. The parallelisms have been noted by Barrande, Bronn, and many conchologists, who can furnish a much more full table than the following, from the most recent sources:

NAUTILI.		AMMONITES.
	A. The shell straight, unwound.	
Orthoceras.		Baculites.
	B. The shell more or less curved or wound.	
	α. Simply curved.	
Cyrtoceras, Phragmoceras, }		Toxoceras.
	αα. A more or less straight portion, folded on the remainder.	
	β. Folded portion in close contact with remainder.	

* We owe very many observations on the Marsupials to Owen.

Ascoceras.		Ptychoceras.
	ββ. Folded portions not in contact.	
?	?	Hamites.
	ααα. One extremity spirally wound, the volutions not in contact.	
	β. Extremity of the shell prolonged beyond the wound portion.	
Lituites.		Ancyloceras.
	ββ. Extremity not prolonged in a line.	
	γ. The spiral flat.	
Gyroceras.		Crioceras.
	γγ. The spiral elevated (heliciform).	
Trochocerus.		Turrilites.
	αααα. Spiral turns of the shell in contact.	
	β. Extremity prolonged in line beyond the spiral.	
*	*	Scaphites.
	ββ. Extremity not prolonged beyond spiral.	
Nautilus.		Ammonites.

We may now consider the question of the origin of these higher groups. In the first place, we must lay down the proposition *that the characters which constitute groups "higher" in the comparison of rank* (we do not of course mean higher in the same line, as we say higher genus in a family, or higher order in a class) *are such solely from their being more comprehensive, or present throughout a greater range of species.*

What is true, therefore, in respect to characters of genera, is likely to be true in respect to characters of higher groups, such as we have been considering in the preceding pages. Believing, then, that a new genus has been established by the transition of a number of species of a preceding genus in order, without necessary loss of specific characters, I think the same process may have established the suborders and orders in question. That is, *that a large number of genera have near the same time, in past or present geological history, passed into another suborder or order by the assumption or loss of the character or characters of that to which they were transferred, and that without necessary loss of their generic characters.*

I will cite a probable case of this kind, the facts of which I have already adduced.

It has already been shown that the genera of six of the families of the Batrachia Anura form series characterized by the successive stages of ossification of the skull, terminating in a dermoössified condition, with over-roofed temporal fossæ. That in nearly all the other families similar relations between genera exist, but are nowhere carried so far. The character attained by all the first series is now only generic, but should all the genera of each of the six families assume this character in time, as is necessary in accordance with a development hypothesis, it would at once possess a new and higher importance, and would become ordinal or otherwise superior. It would define a series homologous with all those types which had not attained it. This character of the over-roofing of the temporal fossæ has actually attained a family significance among the Testudinata,—*e. g.*, as defining the marine turtles; and similar characters are found by Owen to characterize the Labyrinthodontian order of Batrachia.*

Agassiz has pointed out a similar and more extended case, in the Heterocercal and Homocercal ganoids. Had we not so many of the closest approximations between members of these groups, they would stand in the systems

*The roof here alluded to by Owen includes some two distinct bones not known in the arch of the Anura, and therefore different. It is, however, enough to know that this structure is serially associated with its absence and rudimental appearance in the tailed Batrachia of the present day, to make the comparison apposite.

as two great homologous series, with their contained heterologous genera. As it is, these heterologous terms or genera are evidently so nearly allied that Agassiz, in the Poissons Fossiles, has thought it best to arrange the latter together, thus instituting a system *transverse*, as it were, to the other. This may be necessary, since Kölliker points out transitional forms, and perhaps certain types may have begun to abandon the heterocercal form near the period of reproduction, producing offspring somewhat protean in character, preparatory to an earlier appearance and consequent permanence of the homocercal type. This is to be derived from the history of the metamorphosis of Amblystoma.

In the same manner the development of the convolutions of the brain does not define groups of the highest rank, since it progresses chiefly during the later periods of embryonic life, and is therefore a "developmental character." Owen has endeavored to distinguish the primary divisions of Mammalia by the character of these convolutions, whereas they really define only the subgroups of the orders. For we have Lissencephalous (smooth-brained) monkeys,—certain lemurs,—and smooth-brained Ruminants,—*i. e.*, the extinct Brachyodon and Anoplotherium, according to Lartet and Gratiolet. (The lowest types of the existing smooth-brained Mammalia, including especially those with no or rudimental corpus callosum, the Marsupials, are also distinguished by the non-developement of the deciduous teeth* (excepting one premolar). If now through some topographical change the whole series of Mammalia between the smooth-brained and convolute-brained were lost to us, as by the elevation of a region, and the absence of favorable localities or bodies of water for the preservation of their remains, we would have to study two homologous groups, with the heterologous terms of each corresponding with each other, as do now the genera of the Clamatores and Oscines, of the Arcifera and Raniformia, etc.

In the same way the characters defining Implacental Mammalia will be found transitional in some type, and this great series, homologous with the Placentals, will have to be placed in closer connection, in its genera, with the series of the latter, with genera of the same, perhaps now extinct.

γ. *Of mimetic analogy.*

It has been often remarked that the animals of the Equatorial Ethiopian region were very generally of smoky and black colors. This is remarkably the case, and the peculiarity of the genus Homo in this respect is shared by birds, reptiles and fishes in a remarkable degree. This cannot be traced to the effect of torrid climate, for the same latitudes in India and the Malaysian Archipelago, and in South America, do not produce such colors.

The similarity in color of desert types has also been remarked. The grey sand-hue so well adapted for concealment is universal, with few variations, in the reptiles of the Tartar and Arabian deserts, the great Sahara, and the sands of Arizona and California. There is also a tendency to produce spiny forms in such places; witness the Stellios and Uromastix and Cerastes of the Sahara, the Phrynosomas and horned rattlesnake of south-western America. The vegetation of every order, we are also informed, is in these situations extremely liable to produce spines and thorns.

The serpents of the Neotropical Region furnish remarkable illustrations of mimetic analogy. All the species of the genera Elaps, Pliocercus, Oxyrrhopus, Erythrolamprus, and many of those of Ophibolus and Rhabdosoma are ornamented with black and yellow rings on a crimson ground. The species of all these genera are harmless, except in the case of Elaps, which is venomous. We may give for this genus, as the most varied, the following range of variation in coloration:

* This I have inadvertently alluded to (p.) as the non-development of the permanent series; the homology of the dental system of Marsupials appears, however, to be with the latter, and not with the milk series. See Flower, Trans. Roy. Soc. 1867.

Pairs of black rings;	*Single black rings, far apart*	*Single black rings, very close*
	Elaps corrallinus. b	Elaps mipartitus. d
	nigrocinctus. c	
	Pliocercus equalis. c	Pliocercus euryzonus. d
Opheomorphus mimus. d		
	Oxyrrhopus ?	Oxyrhopus petolarius. d
Erythrolamprus venustissimus. a	Erythrolamprus albostolatus. b	Scolecophis zonatus. a
Ophibolus polyzonus. a		Leptognathus anthracops. a
Xenodon bicinctus. b		

Single black rings with faint laterals.	*Black rings in threes.*	*Single black rings about equal to intervals.*
Elaps fulvius.	Elaps lemniscatus. b	Elaps.
elegans. a		Pliocercus dimidiatus. a
Pliocercus elapoides. a		Catostoma semidoliatum. a
	Oxyrrhopus trigeminus. b	Oxyrrhopus sebæ. d
		Ophibolus pyrrhomelas. h
		Chionactis occipitale. h
		Sonora semiannulata. h
		Contia isozona. h
		Chilomeniscus ephippicus. h

Species a, from Mexico and Central America.
" b, " Brazil, Venezuela.
" c, " Central America.
" d, " western side of Andes.
" h, " Arizona and Sonora.

Many of the species in the same column are exceedingly similar, and some have little (perhaps nothing) to distinguish them but generic characters. The most similar are almost always from the same sub-region.

Similar analogies have been pointed out by Bates among the Lepidoptera of Brazil, and by Wallace among those of Borneo and Celebes, etc. I call attention to these authors here without copying them, as they will repay perusal in the originals.

A case of analogy which may belong to this class is that of the three genera Chelys among tortoises, Pipa among frogs, and Aspredo among Siluroid fishes, species of which inhabit at the same time the rivers of Guiana. The crania of these genera are similarly excessively flattened and furnished with dermal appendages, and their eyes are very minute. The singular similarity need only be mentioned to those familiar with these genera, to be recognized.

The bearing of the Mimetic analogy on the question of transition of types in the developmental hypothesis, is its demonstration of the independence of generic and specific characters of each other, which may suggest the possibility of the former being modified without affecting the latter.

These facts might have been introduced under Sect. II*α*, but they illustrate the general laws of the present section.

IV. *Of natural selection.*

α. As affecting ordinal and class characters.

The second law which may be supposed to have governed a descent with modification, in the production of existing genera, is the force which the will of the animal applies to its body, in the search for means of subsistence and protection from injuries, gradually producing those features which are evi-

dently adaptive in their nature. This is part of the "natural selection" of Darwin.

That this law is subordinate to the one first propounded must, I think, be evident to any one who studies the assumed results of the workings of both, as seen in the characters of genera. It is sufficiently well known that the essential features of a majority of genera are not adaptive in their natures, and that those of many others are so slightly so as to offer little ground for the supposition that the necessity has produced them.

Both laws must be subordinate to that unknown force which determines the direction of the great series. If a series of suppressions of the nervous and circulatory systems of beings of common birth produced the "synthetic" predecessors of the classes of vertebrata, the direction towards which the highest advanced, or its ultimate type, can be only ascribed as yet to the divine fiat. So far as we can see, there is no reason or law to produce a preference for this direction above any other direction.

If from these fixed bases descendants have attained to successive stations on the same line of progress, in subordinate features of the nervous and circulatory systems, constituting the "synthetic" predecessors of the orders in each class, the type finally reached seems to rest on no other basis than the pleasure of the Almighty.

β. As affecting family characters.

If from the single species generalizing a modern order we attempt to deduce synthetic predecessors of existing families, we find some difficulty, if we attempt to see in these stages a uniform succession of progress. A suppression of some features, and advance in others, in one and the same individual up to the period of reproduction, would produce offspring divergent from the start, and represent the relationship of families as we find them.

γ. As affecting generic characters.

If the extremes of our series of genera were characterized by structures particularly adapting them above all others to some cotemporary necessity of existence, this second law, or Darwin's, might be regarded as primary. But the writer's experience of comparative anatomy has led him to believe that this is not the case, as expressed in Proposition IV.

This view has not been overlooked by Darwin, who, however, treats of it very briefly, and appears to attach it to the theory of adaptations, or modifications for a physiological purpose. He says, Origin of Species, 388 (Amer. Edit. 1860): "We may extend this view to whole families, or even classes. The fore-limbs which served as legs in the parent species may become, by a long course of modification, adapted in one descendant to act as hands, in another as paddles, in another as wings; and on the above two principles,—namely, of each successive modification supervening at a rather later age, and being inherited at a correspondingly late age,—the fore-limbs in the embryos of the several descendants of the parent species will still resemble each other closely, for they will not have been modified. But in each individual new species the embryonic fore-limbs will differ greatly from the fore-limbs in the mature animal; the limbs in the latter having undergone much modification at a rather late period of life, and having thus been converted into hands, paddles or wings." He then inclines to assign this change to the necessity of external circumstance. But such modification must be the same in kind as others, which the same hypothesis must explain, and of which the same author remarks (p. 382): "We cannot, for instance, suppose that in the embryos of the Vertebrata the peculiar loop-like course of the arteries near the branchial slits are related to similar conditions in the young mammal, which is nourished in the womb of its mother, in the egg of the bird which is hatched in a nest, and in the spawn of a frog under water. We have no more

reason to believe in such a relation than we have to believe that the same bones in the hand of a man, wing of a bat, and fin of a porpoise, are related to similar conditions of life. No one will suppose that the stripes on the whelp of the lion, or the spots on the young blackbird, are of any use to these animals, or related to the conditions to which they are exposed."

The law of natural selection, however, has no doubt been a very important agency in the production of organic types in different periods of the world's history, but the part it has played in the determination of generic features would appear to have been very small.

In its first effect,—that of producing a structure adapted for a particular purpose,—it would seem to have acted differently to produce the same results, and hence not to have produced any of the more extended groups, as families, where hundreds of species are identical in a single feature. Witness the differences in diverse types of the tree-frogs, each type adapting its possessor to an arboreal life:

I. Claw-like, with globular base..............	HYLIDÆ.
	Leptopelis.
II. Simple, obtuse-depressed at tip....................	RANIDÆ. I *aa* and III *a.*
III. With a terminal transverse limb..................	RANIDÆ, *Hylarana* et aff.
	Callula.
	Brachymerus.
	Hylodes.
IV. Bifurcate........	*Batrachyla.*
	Dendrobates.
	Polypedates.
	Rhacophorus.

The short foot of the Testudinidæ, where one row of phalanges is omitted, has been already alluded to. The gradual reduction of this set of bones, accompanying general modification of form in the increased convexity of dorsal region, as we leave the more aquatic and progress towards the terrestrial tortoises, would seem to be intimately connected with difference of habit. The increased convexity of carapace is an increased defence from falling objects,—a danger to which land tortoises are far more subject than the aquatic. Another protection not needed by water tortoises so much as by terrestrial, is the faculty of closing one or both free lobes of the plastron, as seen in the Cistudo, Sternothærus, etc., or of portions of the carapace, as in Pixys, Cinixys, etc. This might really have been produced by excessive tension on the sternal and pelvic muscles while young, and while the sutures were not fully interlocked. This, continued for a long time, might have produced the result. Yet it is not easy to see what protection the aquatic Uronyx and Platythyræ need in this respect, above the Emydes of the same countries. The backs of these genera are also as convex as are many of the terrestrial genera or Testudinidæ.

I cannot better express my views than by quoting the following from the pen of the late Dr. Falconer. It is extracted from one of his essays on the Elephantidæ.*

"Each instance, however different from another, can be shown to be a term of some series of continued fractions. When this is coupled with the geometrical law governing the evolution of form, so manifest in shells of the Mollusca, it is difficult to believe that there is not in nature a deeper seated and innate principle, to the operation of which natural selection is merely an adjunct.

"The whole range of the mammalia, fossil and recent, cannot furnish a species, which has had a wider geographical distribution, and, at the same time, passed through a longer term of time and through more extreme changes of climatal conditions than the mammoth.

*See writings of Hugh Falconer, vol. ii. (Ed. by Murchison.)

"If species are so unstable and so susceptible of mutation through such influences, why does that extinct form stand out so signally a monument of stability? By his admirable researches and earnest writings, Darwin has, beyond all his cotemporaries, given an impulse to the philosophical investigation of the most backward and obscure branch of the biological sciences of his day; he has laid the foundation of a great edifice; but he need not be surprised if, in the progress of erection, the superstructure is altered by his successors, like the Duomo of Milan, from the Roman to a different style of architecture.

"The inferences which I draw from these facts are not opposed to one of the leading propositions of Darwin's theory.

"With him I have no faith in the opinion that the mammoth and other extinct elephants made their appearance suddenly, after the type in which their fossil remains are presented to us. The most rational view seems to be, that they are in some shape the modified descendants of earlier progenitors. But if the asserted facts be correct, they seem clearly to indicate that the older elephants of Europe, such as E. meridionalis and E. antiquus, were not the stocks from which the later species, E. primigenius and E. africanus sprung, and that we must look elsewhere for their origin. The nearest affinity, and that a very close one, of the European E. meridionalis, is with the miocene E. (Loxod.) planifrons of India, and of E. primigenius with the existing Indian species.

"Another reflection is equally strong in my mind, that the species by 'natural selection,' or a process of variation, from external influences, are inadequate to account for the phenomena. The law of Phyllotaxis, which governs the evolution of leaves around the axis of a plant, is nearly as constant in its manifestation as any of the physical laws connected with the material world."

δ. *As affecting specific characters.*

As I have hitherto attempted to prove, that the higher grade of groups, or, in other words, the higher grade of characters, could not have had their origin through natural selection alone, though admitting it as a conserving or restricting principle, I now come to ground where natural selection must be allowed full sway. The "origin of species" is not the object of this essay, as a greater has gone before me, and has done a great deal towards showing that a selective power, dependent on adaptation and teleological relation, has favored or repressed, or even called into existence, the varied peculiarities that characterize species and races. I will therefore only refer to his well known works on the Origin of Species and the Modifications of Animals under Domestication.

I may add that it is within the range of possibility that that grade or kind of characters found to define the *family* group, may be more or less the result of natural selection.

Acceleration and retardation is also far from excluded from the probable causes of specific characters. The species of many genera do exhibit a proportion of characters which are the successive stages of that one which progresses farthest, as the species of Amblystoma in the position of their teeth, nostrils, form of tail and coloration; of Hyla in form of vomerine teeth, etc. But the majority of specific characters are of divergent origin,—are "morphic" as distinguished from developmental.

ε. *On metaphysical species.*

One of the arguments employed against the developmental hypothesis in any form, is that that inherent "potentiality" which causes that like shall always produce like, is a metaphysical being, which cannot be transformed, and which holds the structure which it vivifies as a material expression or stamp of itself, and which therefore cannot be changed.

One expression of this inherent metaphysical specific individuality, if the term may be allowed, has been said to be the peculiar traits of the intelligence of species, their motions, voices and instincts. But intelligence of all animals is susceptible of impressions, the lower the intelligence the less susceptible, and the more automatic. But as we rise in the scale of animal being this impressibility and capacity for education is undeniably exhibited by the dog, horse and all the well known domesticated companions of man. There can, in view of the capacities of Aves and Mammalia in these respects, be little doubt that all animals are educated by the "logic of events," that their intelligence, impressed by changed circumstances, can accommodate itself more or less to them, and that there is nothing in this part of their being opposed to the principle of "descent with modification."

There is another difficulty in the way of accepting metaphysical peculiarity or progenitiveness as isolating species. It is marked often strongly in races or varieties, which no one pretends to have had distinct origin. Here like produces like continually, though not persistently, but sufficiently to show that it resides in varieties of common origin. The isolation of allied species in fact depends, we believe, solely on the supremacy of the automatic over the intelligent spirit. When the intelligent rises above the bounds of nature, or the automatic, the mixture or separation of allied species depends merely on circumstances of necessity, determined by that intelligence.

But the metaphysical "potentiality" loses all basis, if the law of acceleration and retardation be true, for in accordance with it, in the fullness of times *like does not produce like.*

V. *Of Epochal Relations, or those measuring Geologic Time.*

If it can be shown that groups having the developmental relation above insisted on are cotemporaries, and if it can be shown that this relation is identical in kind with that which we regard as measuring the successions of geologic time, we will be led to doubt the existence of any very great interruptions in the course of this succession throughout geologic time. And if we can show that faunæ so related are more or less characteristic of distinct portions of the earth's surface, at the present time, we will be led to anticipate that cotemporaneous faunæ in different regions, during geologic periods, also bore such a relation. If this proposition be true, we are led to the further conclusion, which is at variance with received canons, that identity of faunæ proves successional relation in time, instead of synchronism.* That this will ultimately be demonstrated appears highly probable to the writer, though, as yet, the evidence is but fragmentary.

If the relations expressed under the terms homology and heterology, taken together with the observations on metamorphosis, render it probable that a number of genera have reached their *expression points*, or periods of metamorphosis, at near the same time in geologic history, an important point has been gained. If we can render it probable that a change in any organic character has been nearly simultaneous throughout a large extent of specific forms, the change becomes, on the latter account alone, of higher than generic value, but characteristic of such groups as Marsupialia, Clamatores, Acrodonta, Arcifera, Heterocerca and the like.

We have here, also, an important element in the estimation of the value of apparent interruptions in the geological history of the life of the globe. These interruptions, it is true, are greater than any such theory as the present can bridge over; yet such a theory, if true, lessens their importance. They are in any case well accounted for on the theory of the existence of periods of elevation, during which the life of a given region is necessarily almost entirely lost to us, through lack of means of preservation of their remains.

*This view was first propounded by —— and has since been reaffirmed by Huxley.

We may also compare such extended metamorphoses with those of cosmica matter, such as when, in the course of ages, a primæval vapor has in a short time collapsed to the liquid form, or as when the vast of liquid in turn has shrunk to its solid condition; both alike for ages approaching their change, yet stationary in external relations till the moment of transition has arrived.

The following are the zoölogical relations of the groups already compared :

The most generalized group of fishes of the Regio Neotropica is that of Characins. Its type, in respect to fin structure, which is common to all the Malacopterygians, is that of an undeveloped stage of the Acanthopterygians, the adipose fin being an undeveloped cartilaginous fin and the cartilaginous fin an undeveloped spinous fin.* It may be said to be the highest among Malacopterygians if we look to the complete oviducts, opercula, jaws, etc., but it is the lowest as removed farthest from the extreme of Malacopterygian peculiarities, as being most generalized or embracing representatives of all the rest, and approaching nearest the types of the past—the Ganoids. For example, Butyrinus and Vastres may be compared with Amia. The family is distributed chiefly in the Southern Hemisphere.

The genus Orestias, which Agassiz says is characterized by a feature which exists in the immature state of all other Cyprinodonts,—the absence of ventral fins,—is only found in the Neotropical region.

Of the venomous serpents, the inferior group, the Proteroglypha, belong to the Southern Hemisphere, and the Australian and Neotropical regions almost exclusively embrace by far the greater proportion. Australia contains none other.

The Iguanian lizards are lower than the Acrodont, exhibiting a larval type of dentition, and one characteristic of all lower Sauria and Batrachia. The only acrodont type of Ophiosaura (Trogonophis) is Old World.

The New World Teidæ have not the extent of ossified temporal roof that their representatives, the Old World Lacertidæ have. So the chiefly Neotropical Anguidæ have the tongue partly of papillose type of their Old World representatives, the Zonuridæ, and partly the smooth or scaly type of the cosmopolite Scincidæ, which are inferior to them.

The snake-like forms of the families of the Lacertilia Leptoglossa greatly predominate in the Southern Hemisphere; also those with undeveloped palpebræ.

The Neotropical type of Testudinata is quite coincident with the family Characinidæ in relations. It is, like it, largely distributed over the Southern Hemisphere, and like it may be regarded, in respect to its pelvic pecularities, as higher than the remaining types, but in its generalized character and relationship to the past periods may be called lower.

The Neotropical type of Batrachia Anura, that is the Arcifera, is lower in developmental characters than the opposed series, the Raniformia; such of the latter as are found in its limits partake in some way of larval incompleteness. The Arcifera are chiefly distributed elsewhere in Australia, where no Raniformia exist.† Those genera of Old World Raniformia of the lowest or toothless group, which display the least development of the cranial bones, as Brachymerus and Breviceps, are of the Southern Hemisphere—South African.

The Pullastrine birds are a generalized group, inferior to the group op-

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* Kner Ueber den Bau der Flossen.

† The *Eucnemis bicolor* Gray would appear to be an exception, were its generic and subordinate affinities truly represented by its name. I have examined the type specimen through the kindness of Dr. Günther, and can state that it is nor an Ixalus (= *Eucnemis*), and does not even belong to the Raniformia, but is an Arcifer of the family Hylidæ. If it be not a young Calamita or Hyla, it will be a Hylella near the H. carnea type.

Günther states that Hylorana erythraea has been found at the extreme northern point—Cape York—of Australia. If so, the case is parallel to the occurrence of the Raniform Ranula in northern South America.

posed to them—the Gallinæ. Their typical forms, like the last, are distributed to the Neotropical and Australian regions: the outliers (pigeons) are not so numerously distributed in the other regions.

The Struthious birds, the most synthetic of the class, belong exclusively to the Southern Hemisphere; as is well known, they chiefly abound in Australia and its adjacent islands, with an abundant outlying type—the Tinamus—in South America.

The penguins, which only of all birds display the divided metatarsus, inhabit the Antarctic regions and Cape Horn.

The Clamatorial type of the Passeres exhibit larval characters in the non-developmeht of the singing apparatus, and the scaled or nearly naked tarso-metatarsus. These are chiefly South American.

Of Mammalia, the placentals without enamel on their teeth, which, in this respect, never reach the full development of the class, whose dentition is also monophyodont, *i. e.*, the Edentata, inhabit only the Southern Hemisphere, and almost altogether the Neotropical region. The implacental Mammalia, also (except in one tooth) monophyodont, which approach birds and reptiles in so many respects, are confined to the Southern Hemisphere, and chiefly, as all know, to Australia.

Of the Quadrumana, the Platyrrhine group is known to be inferior to the Catarrhines: the farmer presents an entirely embryonic condition of the *os tympanicum*, which is passed by the latter in early age;* it contains also the only clawed genus of the true monkeys. It is confined to the Neotropical. To Madagascar, also of the Southern Hemisphere, and nearest in many ways to the Neotropical, pertain the lowest families of the Quadrumana, the Lemuridæ and Chiromyidæ; the former presenting brains without convolutions, and approaching in many ways the Insectivora; the last imitating, at least, a Rodent.

There are also other reasons for the inferiority of South America. Its deer, which are few, are those which never produce more than the "dague," or the first horn of the northern Cervus, or those which never get beyond the fourth step in the development of the lower group of R. Nearctica.

The Loricariidæ of South America, I am informed by Prof. Agassiz, possess the fœtal pupil of the vertebrate type.

If we glance at Coleoptera we find the great predominance of the groups with undeveloped tarsus, the three and four-jointed Trimera and Tetramera, and of the lower group with undeveloped sternum,† the Rhynchophora, in the Neotropical region.

Among Lepidoptera it is known that the most gigantic of the species of the Neotropical region are Noctuidæ (Erebus, etc.), and that in that region this low type of the order reaches its greatest development. The largest forms of the Regio Nearctica, as well as Palæarctica, are representatives of the higher type of the Saturniidæ (Attacus, Telea, etc.), while the largest and most powerful of this order in the Palæotropical (Indian) region are the Papilionid forms of Ornithoptera, etc., the generally admitted crown and head of all. Of course other types, both higher and lower, are largely developed in each and all of these regions, and the significance of the above facts is perhaps only to be seen when taken in connection with a large number of others pointing in the same direction.

Two or three comparisons of different faunæ may be brought forward finally. First, returning to the birds, a survey of some of the differences between the birds of Panama, Pennsylvania and Palestine may be made.‡

Tristram noticed 322 species of birds within the range of the ancient terri-

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* See Dr. H. Allen, Proceed. A. N. S., Philada., 1867.

† Leconte American Association, 1867.

‡ From the American Naturalist, 1868, by the author.

tory of Palestine. Of these 230 were land and 92 water birds, *i. e.*, Natatores and the wading Cursores. Of the 230, 79 are common to the British Islands, and 36 of them are found in China, but a small proportion extending their range to both these extremes. Of the water birds, which are always more widely distributed, 55 of the 92 are British and 57 Chinese. Twenty-seven appear to be confined to Palestine and to the immediately adjacent country; the largest of these is a crow.

Taking the 230 land birds at a glance, we find the utter absence of so many of the well known forms that enliven our grounds and forests. The absence of Tanagridæ and Icteridæ changes the aspect of the bird-fauna at once. What have we here then of nine-quilled Oscines to enliven the meadows like our swarms of blackbirds, or fill the tree tops and thickets with flutter like our wood warblers? Nothing; for the twenty-four species of finches, Fringillidæ, will but balance our own, though the genera are all different but four, and they the most weakly represented by species. We must look to the higher series, the ten-quilled song birds, for the missing rank and file. While a much larger extent of the Eastern United States possesses fifty species of these types, the little Palestine has already furnished a list of one hundred and twenty-eight.

First, of the crows, which verge nearest Icteridæ by the starlings, we have 13 species against five in our district of the United States, and not less than seven of the type genus Corvus, to our one common and two rare. Of these, two are of the larger species, the ravens. If we turn to the cheerful larks, we find the proportion again the same; fifteen species for Palestine and one for the whole United States. One congener of our species occurs there; the other genera call to mind the African Deserts and Russian Steppes. Motacillidæ, again, ten to one against our fauna. *We* have two Tanagridæ to imitate them, beside the true relative. In swallows we are about equal, and in the forest-haunting Paridæ—titmice and wrens—we exceed a little; but the comparison of Sylviidæ and Turdidæ is most striking. These highest of the bird series, especially made to gladden man's haunts with song, exceed in number all the other ten-quilled Oscines together inhabiting Palestine, amounting to seventy-five species. In our corresponding region of the United States nineteen species is the quantum. It is true no mocking bird or wood-robin is known away from our shores, but Palestine has the nightingale, the black-cap and the true warblers or sylvias, which, while they glean from shrub and tree their smallest insect enemies, as do our equally numerous small Tanagridæ, have much louder and sweeter voices.

Our solitary blue-bird represents the long-winged Turdidæ; in the Holy Land there are twenty species corresponding, though none are of our genus. There are indeed but three genera of these two families common to both countries. One of these, Lanius, the butcher-bird, occurs here in one new species, in Palestine in six.

Turning now to a lower series, we look in vain for Clamatorial perchers; that series which gives us the fierce king-bird and querulous pewee, and which peoples South America with thrush and warbler, and shrike and tree-creeper.

In taking a hasty glance over the lower groups, where the carotid arteries begin to be double, as the Syndactyli, we find Palestine too far from the tropics to present us with much array; but in the related zygodactyles our forest-crowned continent must claim great preëminence. It has but a solitary Picus, while we have eight in the immediate neighborhood of lat. 40°, in our Eastern States.

I will close with the birds of prey. Four swamp-hawks, eleven species of falcons, four kites, and eight native eagles, form a list unequalled in the annals of nobility by any land. There are together thirty-one species of Falconidæ, and of Vultures, four. The eagles appear to be all common, among them

the most magnificent birds of prey, the imperial and golden species of these creatures.

To the ornithologist acquainted with the fauna of North America, it will thus be readily perceived that, in comparison, the ornis, just examined, possesses more numerous representatives of the higher groups of the birds, and among lower groups possesses chiefly those of superior grade, or lacks them altogether. Let us, however, compare it with that of Central America, where varied surface and temperature offer even greater opportunity for variety, within quite as restricted an area.

The bird fauna has been found by Messrs. Sclater and Salvin to embrace about 385 species, which is 63 more than were mentioned to occur in Palestine, which is open on three sides to the great contnient. Eighty of 348 land birds are characteristic of Central America; and those which find their kin limited to the Isthmus and adjoining regions of New Grenada and Equador, amount to about seventy-five more. Twenty-seven is the number not known to extend beyond the boundaries of Palestine; as to the Middle States of our Union, not one species has been shown to be restricted within such narrow limits.

A single species occurs in Europe; this is the fish-hawk, an animal which combines the cosmopolite habit of the sea-bird with the powerful flight of the bird of prey. This is also the only species common to the Panama and Palestine catalogues.

The birds of prey are numerous,—twenty-nine species. Among these there is no true eagle or falcon, and of the nineteen genera but four belong to the fauna of the Holy Land. There is but one species to represent the great grouse family, but, instead, three *families* of their South American imitators, the Pullastræ, instead of the one—that of the Pigeons—slimly represented in Palestine, and in North America as well.

Coming to the closer test of superiority, the Passeres,—those delicate creatures, apparently so dependent on those laws which govern increase and provision, and so affected by the changes that man works in the face of nature,—what do we find? We count 106 distinct species. There are none in Palestine. Of songsters, the Oscines, ninety-six species await man's conquest of the wilderness, to increase in numbers and to display their gifts, while Palestine rejoices in a whole army of them. But the contrast is more remarkable if we analyze these forms. Of the Isthmian Oscines, seventeen only hold the first rank, by virtue of their additional, the tenth primary quill, while this feature marks one hundred and twenty-eight species of Palestine. As we rapidly follow the line to the point where its extreme is manifested, in the family of the Thrushes or Turdidæ, Panama is left but two solitary pioneers of these songsters of the North, while seventy-five species represent the family in Palestine.

The comparison between different faunæ exhibits an apparent gradation in some other groups equally curious. Thus the true Cyprinidæ in the Palæarctic region reach a great development, and produce the highest number of teeth on their pharyngeal jaws known, as well as attains the greatest bulk and importance. The number of these teeth is usually seven to five in the inner row; only two or three genera exhibit only four on both. In the Nearctic region the number of teeth is almost always 4—4, more rarely 4—5, and very seldom as high as 5—5. The species of the family are excessively numerous, but are, with scarcely any exception, of small size and weak organism. These statements apply to those of the eastern district of the regiòn between the Rocky Mountains and the Atlantic. Similar types occur in the northern region of the Neotropical,—Mexico, but in no great numbers, but with them the lowest form of the family,—viz., Graödus Günther. This form has no teeth whatever on the pharyngeal jaws. Further south the family disappears, its place being supplied by the generalized family of Characinidæ.

I have already alluded to the great variety of the highest or pentamerous carnivorous beetles in the Palæarctic Region. They are extremely abundant in the Nearctic, while the intermediate territory, the Sonoran and Mexican sub-districts, are the head-quarters of the next lower form, the Tenebrionidæ, which have the tarsal joints 4—5. These give place in the Neotropical to the multitudes of the still lower series,—those with the joints 4—4 and 3—3,—Tetramera and Trimera.

The preceding comparisons indicate that an inherent difference between the types of a continent exists at the present time, though the difference is subordinated to a universal distribution of the higher groups throughout the earth. Has this state of things existed for any long period, or is it a result of different progress in the same group since the human period? This brings us necessarily to a consideration of the truths of palæontology, especially of the last periods, which have been already urged by Darwin. Thus the present fauna of Australia was preceded in the postpliocene and pliocene by forms possessing similar peculiarities, and belonging to the same classes. That is by herbivorous and carnivorous marsupials and monotremes, and by Varanid Sauria, all of greater size than their predecessors.

The same fact is well known of the Neotropical region, its present peculiar Edentata having been preceded by giants of the same type in the postpliocene and pliocene.

In the Nearctic region peculiar existing genera, as Procyon, Alces, Castor, Bos, Sciurus, Arctomys, Lepus, Ovibos, Sorex, Mephitis, Felis, Ursus, Menopoma, Aspidonectes, Crotalus, are represented by postpliocene fossils.

The same occurs in the later Palæarctic formations, where Cervus, Bos, Canis, Mustelidæ, Insectivora, Vipera, Alytes, Triton, etc., are allied predecessors of existing types. In the Palæotropical area a wonderful development of Elephas and Gavialis preceded the same types of the present.

Prior to these faunæ another state of things has, however, existed. North America has witnessed a withdrawal of a Neotropical fauna, and the Palæarctic the retreat of an Ethiopian type. During the postpliocene in North America, Neotropical genera were to Nearctic as 12 to 29, as the record now stands. In the pliocene beds of Pikermi (Greece) antelopes, giraffes, rhinoceros, hippopotamus, huge manis,* monkeys, monitors, and other genera and species of African relationship are the prevailing forms.

Still earlier, a strong mingling of Nearctic, and more of Neotropical types, abounded in the Palæarctic. The genera Chelydra, Andrias, Podocnemis,† Platemys, Caviiform, Psammoryctid and Hesperomys-like Rodentia, Opossums, and Raccoon-like Carnivora.

We have, then, three important terms from which to derive a theory of the creation: 1, the existing six faunæ bear in many of their parts developmental relations to one another; 2, they were preceded immediately by faunæ similar to them in each case, but more remotely by faunæ like that now next lower.

On the whole, there can be no doubt of the truth of the generalization, 1st, *That the Southern Hemisphere is a geologic stage behind the Northern Hemisphere in progress*, on account (1) of its perfection in types extinct in the Northern, and (2) inferiority in modern types prevalent in the Northern.

In order, however, to demonstrate this point more fully, let us examine to what extent the higher types exist in the Southern, and lower or ancient in the Northern.

The Percoid fishes and their allies have Australian and South American representatives in their fresh waters, but they are as mere outliers of the great mass in the Northern Hemisphere. The higher type of venomous serpents (Solenoglypha) occur in both the Æthiopian and Neotropical regions, but they preponderate in the Northern Hemisphere. The higher group of the

* Ancylotherium, Macrotherium.

† P. bowerbankii (*Platemys* Ow.) P. lævis (*Emys* Owen).

Saurians (the Acrodonta) abounds in the Æthiopian and Australian regions; they are as abundant in the Indian and Palæarctic regions of the Northern Hemisphere. In the Southern also, by Uromastix and the Rhynocephalia, they approach nearest the ancient types of the Dicynodontia and the Crocodilia. Lacertidæ, and not Teidæ, occur in the Æthiopian, but they are but a proportion of the whole, which chiefly exists in the Nearctic.

Raniform and not Arciferous Anura populate South Africa; they, however, form but a small proportion compared with the great series of the Nearctic, Palæarctic and Palæotropical regions. It is, however, superior in Anura to the Nearctic, taken by itself.

Rasorial birds and not Pullastræ are the food species of South Africa; but they do not compare in abundance or size with those of the three regions just mentioned.

Moreover, but few Clamatores exist in either Australia or Æthiopia. The Oscine types are abundant, nevertheless they cannot be compared in abundance with those of the northern regions. It must also be remembered that the migratory capabilities of birds render them less expressive of the true nature of any fauna.

The higher family of the Quadrumana, the Simiidæ, replaces in Africa the Cebidæ of the Neotropical; they are, however, most abundant in the Palæotropical region, in the other hemisphere.

There are two ancient or inferior types of the Northern Hemisphere: first, its Ganoid fishes, the Sturgeons of the Nearctic and Palæarctic, and the Gars of the Nearctic. The latter only have representatives in the Southern Hemisphere, Polypterus and Calamoichthys in Africa, and so may be said to be equally distributed; but the former are confined to the north. We do not know, however, whether they are of a modern or an ancient type, nor do we know of extinct sturgeons in the Southern Hemisphere. Indeed, the Ganoid series is not well defined or known as yet. If, as Agassiz states, the Siluroids pertain to it, it is cosmopolitan, though least represented in the Palæarctic.

Second, the Tailed or Urodele Batrachia. This order, entirely characteristic of the Northern Hemisphere, is a group which combines characters of Anura with those of the ancient forms, and possesses in its Nearctic types many of low development. The Gymnophidia of the Southern Hemisphere cannot be considered inferior to them. In the possession of this group the Northern Hemisphere presents its first element of inferiority.

The preceding comparisons indicate also the relations of the regions proper to each other. It is obvious enough that the Æthiopian is much superior to the two others of the Southern Hemisphere. As to the Australian and Neotropical, the former must still be regarded as probably the most ancient, though possessing at the same time a much stronger admixture of northern forms. I have already presented the relations, with the inferior forms of each, thus :*

R. Australis.—Inferior in Monotrematous and Marsupial Mammalia, Pullastriform and Struthious Birds, Serpentiform Pleurodont Lacertilia, Arciferous Batrachia, Pleurodire Tortoises, its Elapid venomous snakes, and the whole Flora, according to Unger.

R. Neotropica.—Marsupial and Edentate Mammalia, Inferior Rodentia and Quadrumana, Pleurodire Tortoises, Pleurodont Lacertilia, Arciferous Batrachia, Clamatorial and Pullastriform Birds, Characin and Erythrinid Malacopterigii.

Conclusions.

The following may be looked upon as conclusions which have been indicated in the preceding pages:

I. Species have developed from preëxistent species by an inherent tendency

* Journ. Acad. Nat. Sci. Philada. 1866, 109.

to variation, and have been preserved in given directions and repressed in others, by the operation of the law of Natural Selection. (Darwin.)

II. Genera have been produced by a system of retardation or acceleration in the development of individuals; the former on preëstablished, the latter on preconceived lines of direction. Or, in other words, that while nature's series have been projected in accordance with the law of acceleration and retardation, they have been limited, modified, and terminated by the law of natural selection, which may itself have operated in part by the same law.

III. The processes of development of specific and generic characters have not proceeded *pari passu*, transitions of the one kind not being synchronous with transitions of the other; and that, therefore, species may be transferred from one genus to another without losing their specific characters, and genera from order to order without losing their generic characters.

IV. And as the heterologous terms of the peculiar homologous groups present an "inexact parallelism" with each other; and as types related by inexact parallelism are each among themselves exact parallels in separate series, whose earliest members present "exact parallelism" with each other, it follows—

V. That the heterologous terms or genera in the later series are modified descendants of those of the earlier series; in other words, that certain groups higher than genera are produced from others of similar high value by "descent with modification."

VI. That the result of such successional metamorphoses will be expressed in geologic history by more or less abrupt transitions, or expression points, rather than by uniformly gradual successions.

Of course, under the conclusion stated in Proposition II, the genus Homo has been developed by the modification of some preëxistent genus. All his traits which are merely functional have, as a consequence, been produced during the process. Those traits which are not functional, but spiritual, are of course amenable to a different class of laws, which belong to the province of religion.

Variations in Taxodium and Pinus.

BY THOMAS MEEHAN.

In some remarks before the Academy on July 14th, in reference to adnation in the leaves of Coniferæ, I said that the power to branch was the test of vigor; and with increased vigor came proportionately the power of adnation. I pointed out that this was the universal law through all Coniferæ, so far as I had been able to examine them; and that it fully accounted for the specific identity of many forms supposed to be distinct. I went so far as to suggest that *Taxodium distichum*, Richard, and *Glyptostrobus sinensis*, Endl., were no doubt the same thing, because the only difference between the growing plants was in the different degrees of adnation in their foliage; and because with this adnation was the increased power to branch observed in all other cases. The two points, going along together, seemed to indicate that this could not be a solitary exception to so clearly marked a law. I exhibited specimens taken from *Taxodium*, and from *Glyptostrobus*, showing the approach of the two in the manner the theory indicated.

Since then some new facts have come before me confirming this view in a remarkable manner. On the nursery grounds of Mr. Robert Buist, of the Darby Road, near Philadelphia, are a few trees which I supposed to be the *Glyptostrobus*, but which Mr. Buist assured me were many years ago, selected by him from a bed of some thousand *Taxodium* on account of their peculiar appearance. I exhibit specimens from eleven different trees. It will be seen the suppression of the leaf blades or adnation is in exact proportion to vigor, or the power of forming branchlets, and with this increased vigor the *Taxodium* become *Glyptostrobus*, so far as any comparison of leaves and branches can identify anything.